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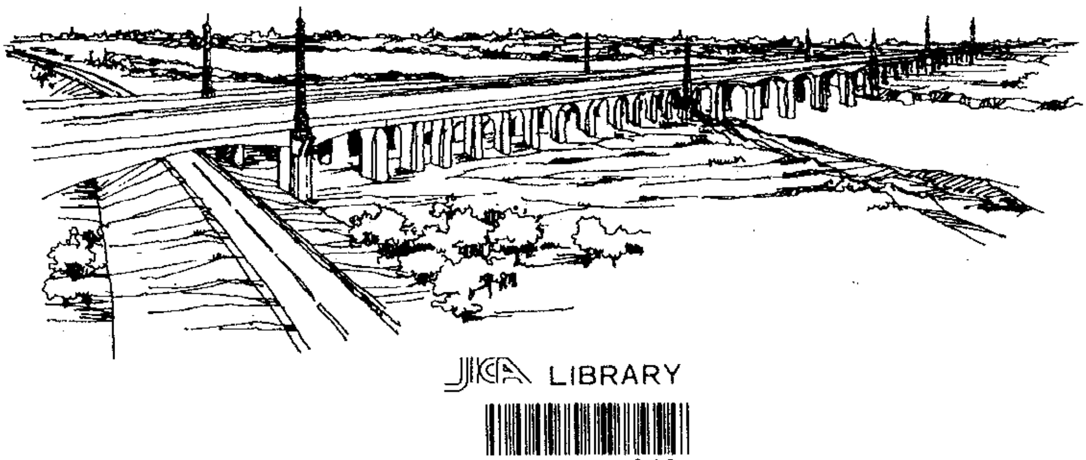
No. 32

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
PROJECT MANAGEMENT UNIT THANG LONG
MINISTRY OF TRANSPORT
THE SOCIALIST REPUBLIC OF VIET NAM

THE DETAILED DESIGN OF THE RED RIVER BRIDGE (THANH TRI BRIDGE) CONSTRUCTION PROJECT IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

VOLUME I : SUMMARY



June 2000

PACIFIC CONSULTANTS INTERNATIONAL

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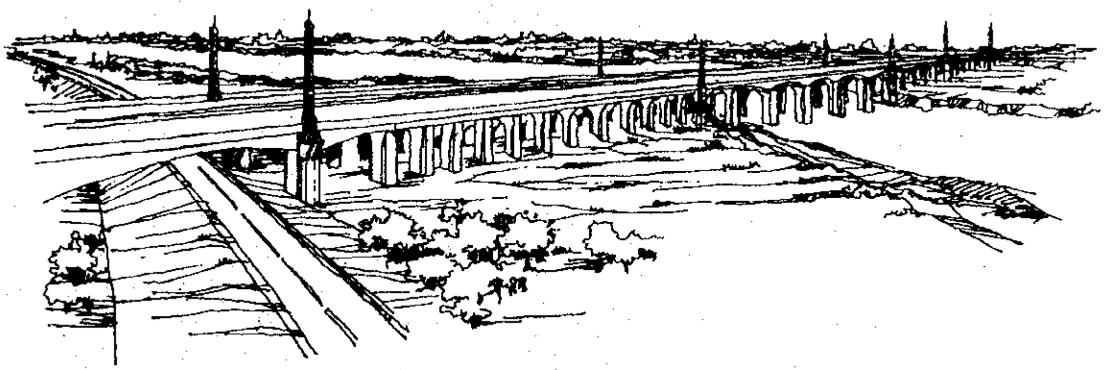

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NOTE

The following exchange rate is applied

US$ 1.00 = VN Dong 14,000
VN Dong 1.00 = JP Yen 0.01
(as of February 2000)

PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a detailed design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam and entrusted to study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Satoshi Watabe of Pacific Consultants International (PCI) to the Socialist Republic of Viet Nam, several times between April 1999 and March 2000.

The team held discussions with the officials concerned of the Government of the Socialist Republic of Viet Nam and conducted field surveys in the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Socialist Republic of Viet Nam for their close cooperation extended to the study.

June 2000

Kimio Fujita
President
Japan International Cooperation Agency

June 2000

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir:

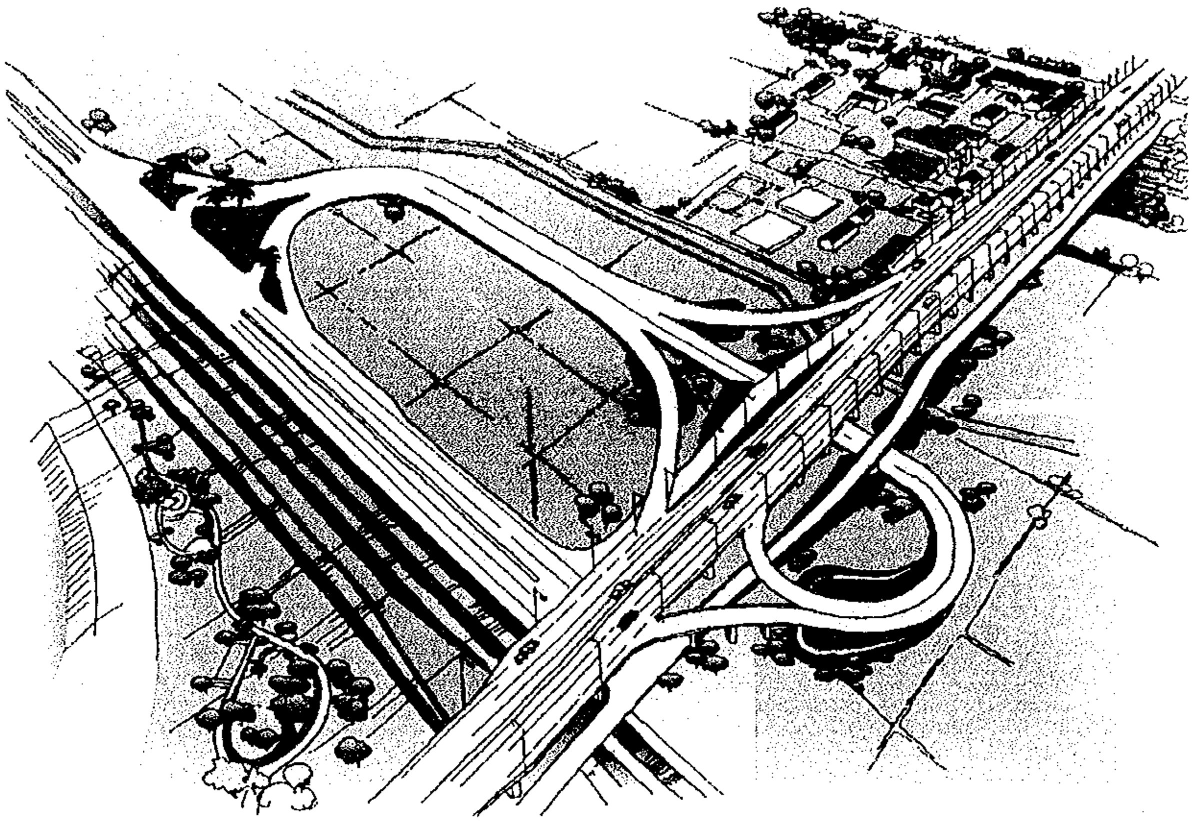
We are pleased to submit herewith the Final Report of Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your agency as well as the formulation of the above mentioned project.

This report presents the result of detailed design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam.

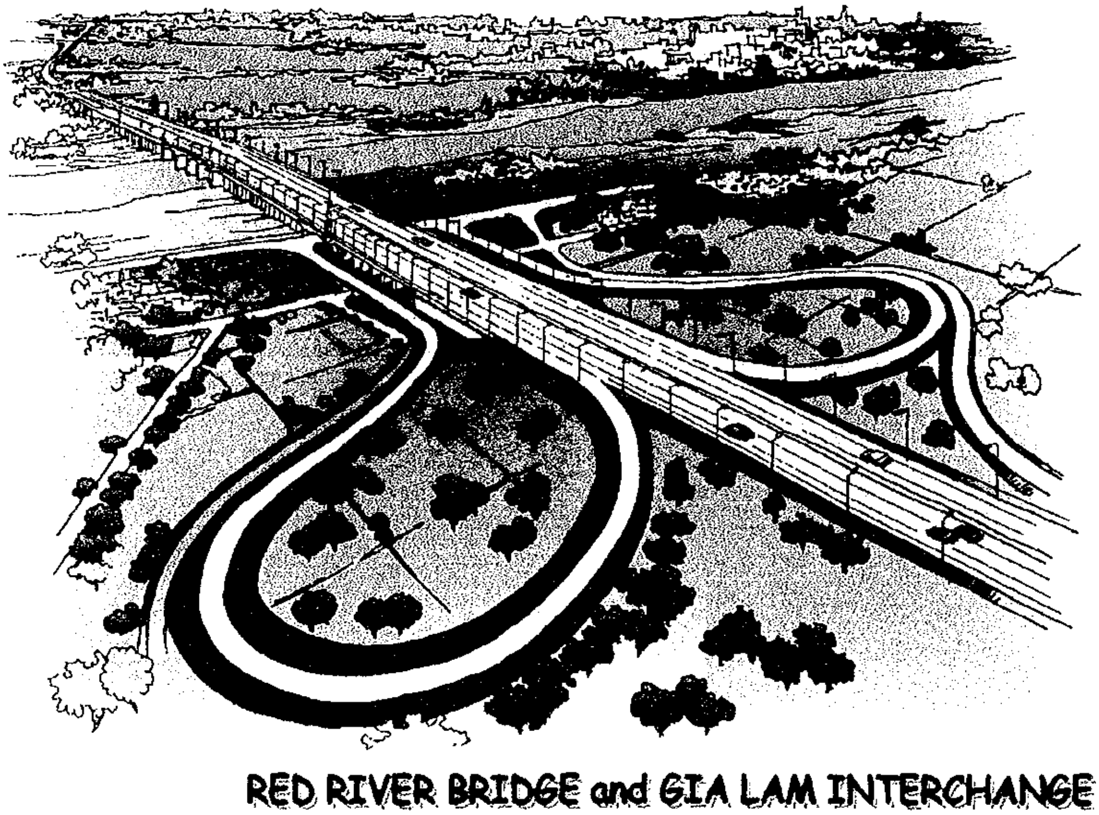
We would like to express our sincere gratitude to your agency and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the officials concerned of Project Management Unit Tang Long, Ministry of Transport of the Socialist Republic of Viet Nam, the Japanese Embassy in the Socialist Republic of Viet Nam for close cooperation and assistance extended to us during our investigation and design.

Very truly yours,

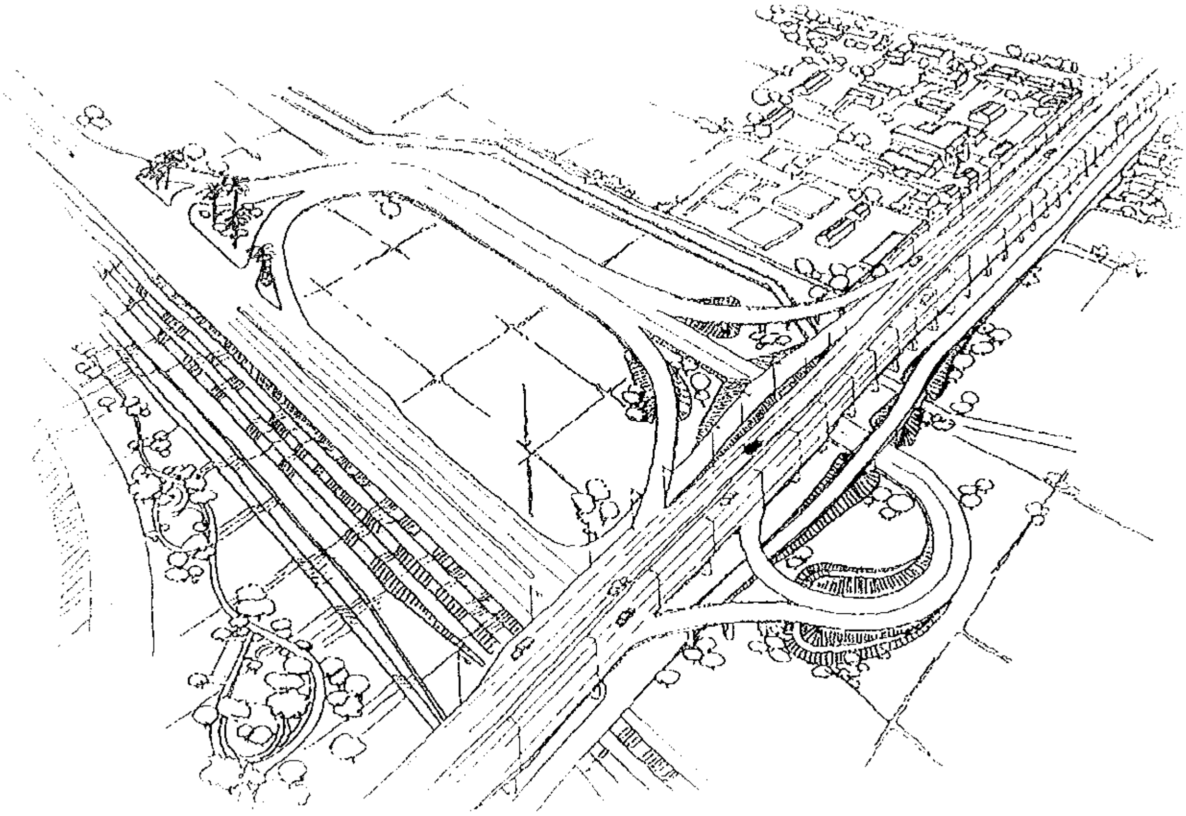
Satoshi Watabe
Team Leader
The Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project
In the Socialist Republic of Viet Nam



PHAP VAN CAU GIE INTERCHANGE



RED RIVER BRIDGE and GIA LAM INTERCHANGE



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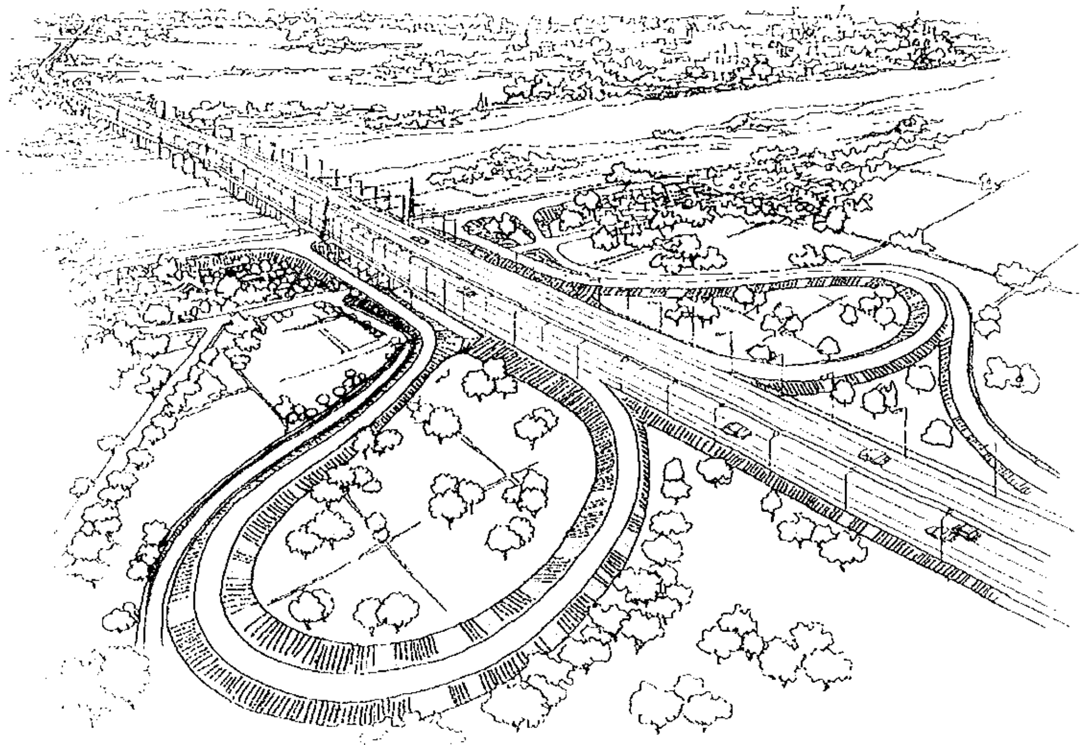
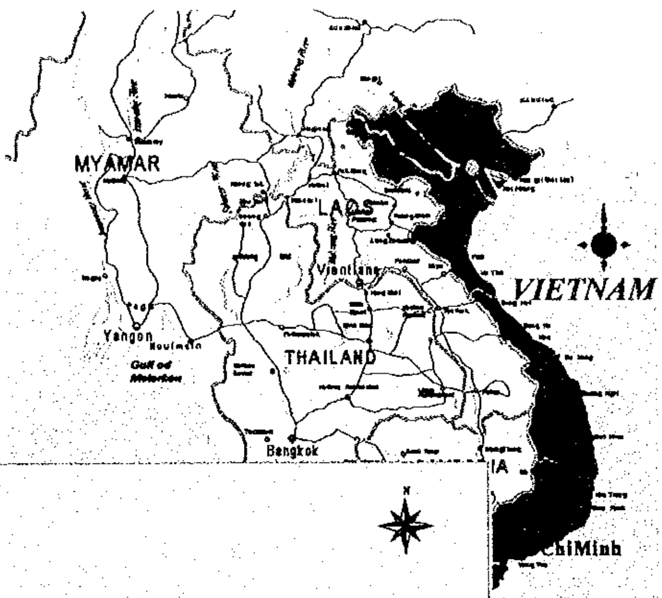
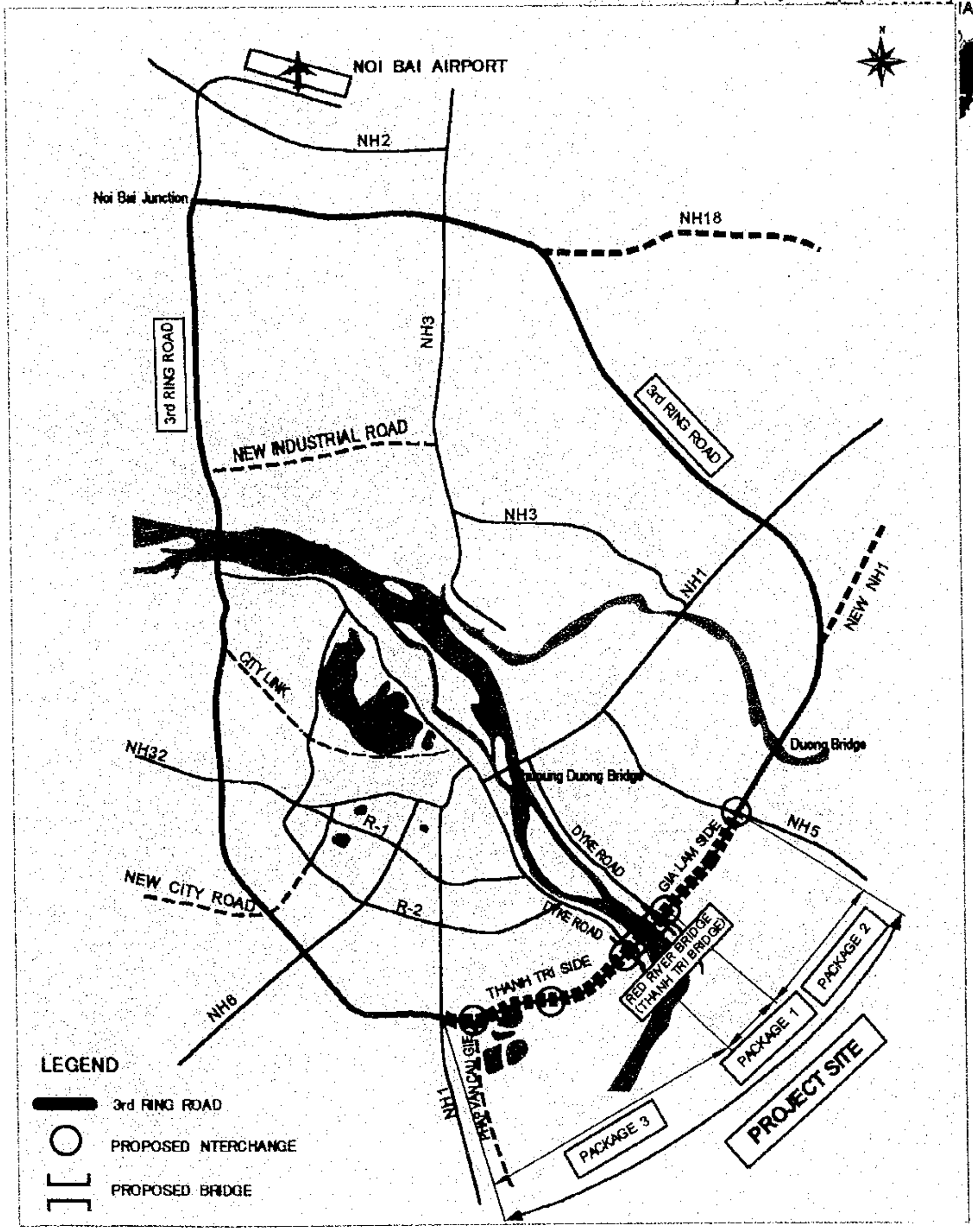


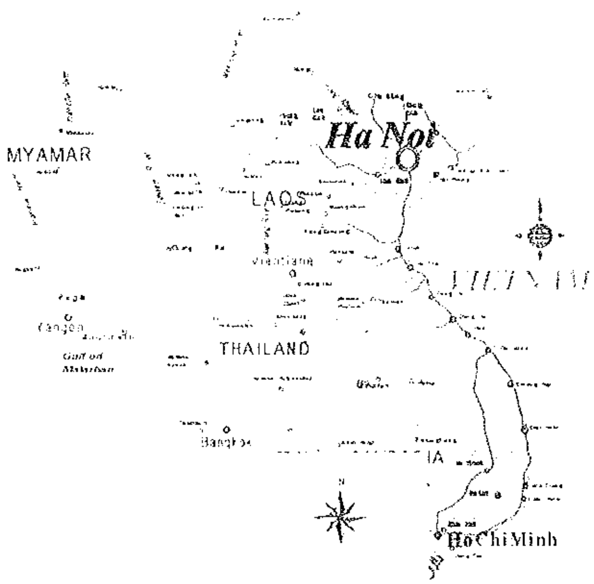
RED RIVER BRIDGE and GIA LAM INTERCHANGE

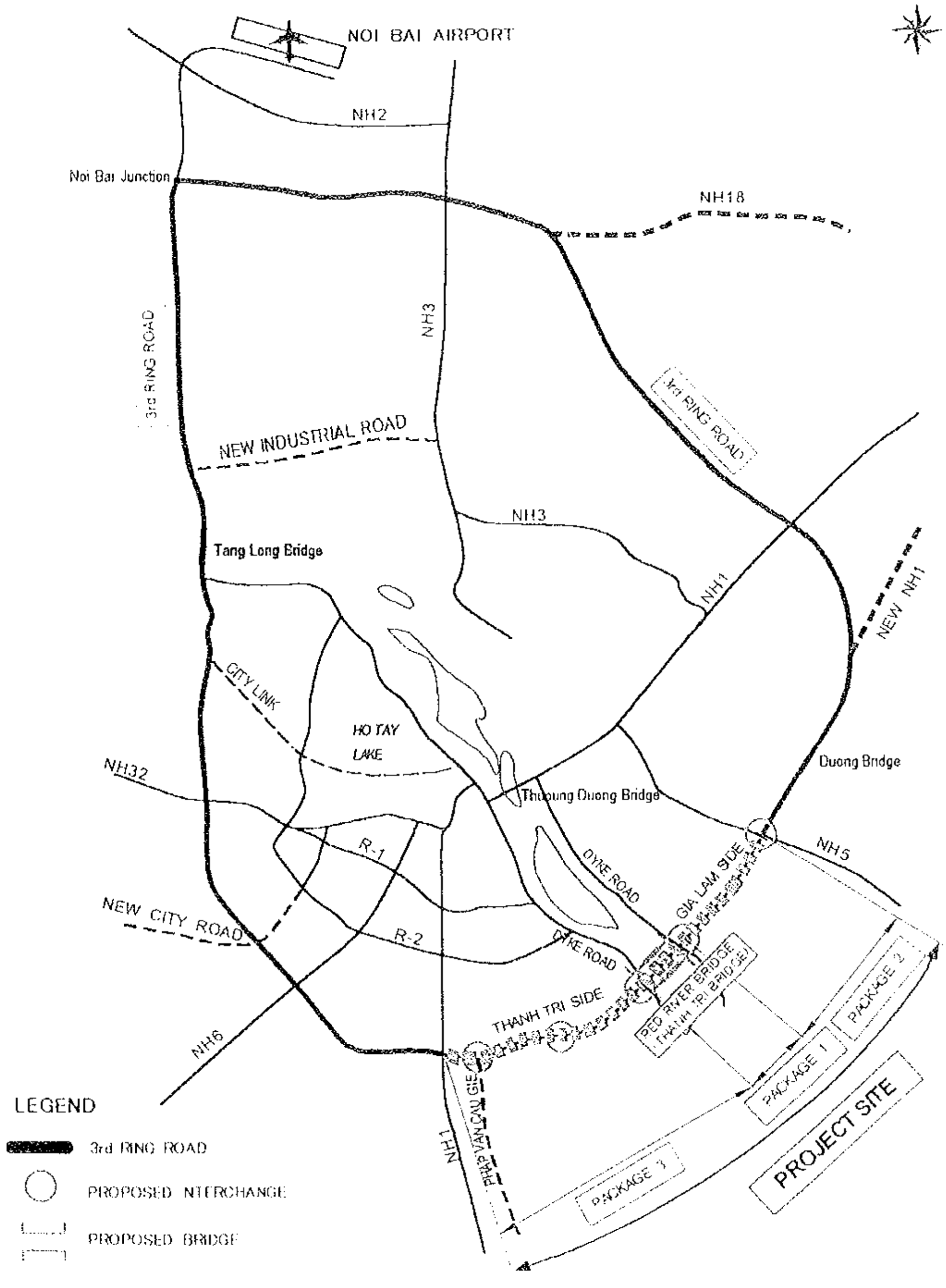
PROJECT LOCATION MAP





PROJECT LOCATION MAP





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ABBREVIATION AND GLOSSARY

(1) Agencies

AASHTO	American Association of State Highway and Transportation
ASTM	American Society for Testing and Materials
ADB	Asian Development Bank
CBD	Central Business District
CPCs	Commune's People's Committees
DOSTE	Hanoi Department of Science Technology and Environment
DLACRCs	District's Land Acquisition, Compensation and Resettlement Committees
DPCs	District's People's Committees
GOJ	Government of Japan
HPC	Hanoi People's Committee
HWBC	Hanoi Water Business Company
HCEC	Hanoi Civil Engineering College
IBRD/WB	International Bank for Reconstruction and Development/ World Bank
JICA	Japan International Cooperation Agency
JBIC	Japan Bank for International Cooperation
JHPC	Japan Highway Public Corporation
MOSTE	Ministry of Science and Technology and Environment
MOT	Ministry of Transport
MOF	Ministry of Finance
MOC	Ministry of Construction
NEA	National Environmental Agency
OMD	Operation and Maintenance Division
PMU Thang Long	Project Management Unit Thang Long
PCs	People's Committees
PED	Executive Division for Implementation of APCRs in PMU Thang Long
PIU	Project Implementation Unit
RMD	Road Management Division
TEDI	Transport Engineering Design Incorporation
TUPWS	Transport and Urban Public Works Services, HPC
UNDP	United Nations Development Program
VRAB	Vietnam Road Administration Bureau, Ministry of Transport

(2) Technial, Traffic and Economic Terms

AADT	Average Annual Daily Traffic
AC	Asphaltic Concrete
ADT	Average Daily Traffic
APCRs	Action Plans for Compensation and Resettlement
B/D	Basic Design
BOD	Biological Oxygen Demand
BP	By-Pass
BH	Bore hole
CBR	California Bearing Ratio
°C	Degree(s) Celsius

CEPT	Center for Environmental Protection in Transportation
DHV	Design Hourly Volume
DPEIH	Drainage Project for Environment Improvement in Hanoi
D/D	Detailed Design
EIA	Environmental Impact Assessment
EIS	Environmental Impact Study
EIRR	Economic Internal Rate of Return
ESAL	Equivalent Standard Axle Load
FIRR	Financial Internal Rate of Return
F/S	Feasibility Study
GDP	Gross Domestic Product
GPS	Global Positioning System
GRDP	Gross Regional Domestic Product
HCM	Highway Capacity Manual of Transportation Research Board, USA
HTRR	Hanoi Third Ring Road
HUTMP	Hanoi Urban Transport Master Plan Study (The Master Plan of Urban Transport for Hanoi City in Vietnam, JICA)
HWL	High Water Level
H/L	Height/span length
IC	Interchange
IP	Intersection Point
ICB	International Competitive Bid
I/L	International Launching
JIS	Japan Industrial Standards
JSHB	Japanese Specifications for Highway Bridges, or DOURO-KYO SHIHOUSHO
kgf	kilogram-force = 9.8 Newton (approximately)
LWL	Low Water Level
LCB	Local Competitive Bid
LPR	Lane Printer
LRFD	Load and Resistance Factor Design
MSL	Mean Sea Level
NH	National Highway
NR	National Route
NPV	Net Present Value
O-D	Origin - Destination
O/M	Operation and Maintenance
Pass. or Pas.	Passenger
PC	Prestressed Concrete
PCU	Passenger Car Unit
PAPs	Project-Affected Persons
P/Q	Pre-Qualification
PSI	Pound(s) per square inch (=lb./in.^{2})
RR	Ring Road
RC	Reinforced Concrete
ROW	Right-Of-Way
SCPT	Static Core Penetration Test
SHTRR	Southern Section of Hanoi Third Ring Road
SPT	Standard Penetration Test
SPM	Suspended Particulate Matter

SMS	Surface-water Modeling System
Sta.	Station
STRADA	System for Traffic Demand Analysis
TCVN	Standard of Vietnam
TCT	Toll collector's terminal
Tf	Ton-force = 9.8 kilo Newton (approximately)
US$/USD	US Dollar
VND	Vietnam Dong
VNBDC	Vietnamese Bridge Design Codes 22TCN 018-79
VOC	Vehicle Operation Cost
WGS	World Geodetic System

(3) Definition

Auxiliary Lane	An auxiliary lane is defined as the portion of the roadway adjoining the traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through traffic movement.
Base	The layer or layers of material placed on a subbase or subgrade to support a surface course.
Bridge	A structure more than 6m long, including supports, spanning and providing passage over a depression, waterway, railroad, highway, or other obstruction.
Capacity	The term "capacity" is used to express the maximum number of vehicles that have a reasonable expectation of passing over a given section of a lane or a roadway during a given time period under prevailing roadway and traffic conditions.
Expressway	The highest type of arterial highway is the expressway which is defined as an express highway fully controlled access. Essential expressway elements include medians, grade separations at cross roads, ramp connections for entrance to and exit from the through pavements for interchange of traffic and (in some cases) frontage roads.
Frontage Road	Frontage roads may be used to function as a street facility serving adjoining property, and to maintain circulation of traffic on each side of the expressway. Frontage roads generally are, but need not be, parallel to the roadway for through traffic, they may or may not be continuous, and they may be provided on one or both sides of the expressway.
Full Control of Access	Full control of access means that preference is given to through traffic by providing access connections only with selected public roads and by prohibiting crossing at grade.

Interchange	An interchange is a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways on different levels.
Intersection	An intersection is defined as the general area where two or more highways join or cross, including roadway and roadside facilities for traffic movements within it.
Median	A median is defined as the portion of divided highway separating the traveled way for traffic in opposing directions.
Ramp	The term "ramp" includes all types, arrangements, and turning roadways that connect two or more legs at an interchange.
Roadbed	The graded portion of a highway prepared as a foundation for the pavement structures.
Roadside	All area within the right-of-way excluding the traveled way and shoulders.
Roadway	The portion of a highway within the limits of construction.
Shoulder	A shoulder is the portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use and for lateral support of pavement.
Subbase	The layer or layers of material placed on a subgrade to support a base.
Subgrade	The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.
Substructure	All of the bridge below the bearings of simple and continuous spans; pier(s) and abutments including wingwalls.
Superstructure	The entire bridge except the substructure.
Surface Course	The top layer or layers of a pavement structure designed to accommodate the traffic load and resist skidding, traffic abrasion, and weathering.
Throughway or Through Pavement	Roadway for the movement of through - traffic, inclusive of shoulders.
Traveled Way	Traveled way is the portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

PROJECT SUMMARY

1. COUNTRY	The Socialist Republic of Viet Nam
2. NAME OF STUDY	The Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project
3. COUNTERPART AGENCY	Project Management Unit Thang Long, Ministry of Transport
4. OBJECTIVE OF STUDY	The Detailed Design and Preparation of Draft Tender Documents for the Project

1. STUDY AREA: The Study area covered Hanoi City and its vicinity where the influence of the Project will be expected.

2. FUTURE TRAFFIC VOLUME

Package No.		1	2	3
Section		Red River Bridge	Gia Lam Section	Thanh Tri Section
Road/Bridge Length		3.1 km	3.5 km	6.2 km
Traffic Volume	Year 2010	73,100	73,100	57,600／73,100 *
(PCU／day)	Year 2020	111,700	111,700	86,400／111,700 *

Note) * Traffic volumes indicate (section between NH1 and Phap Van Road)／(section between Phap Van Road and the Red River Bridge).

3. DESIGN SPEED, NUMBER OF LANE AND TYPICAL CROSS SECTION

Package No.	Section	Design Speed	Number of Lane	Typical Cross Section*2
1	Red River Bridge	100 km／hr	4 (6 *1)	TypeA
2	Gia Lam Section	100 km／hr	4	Type B or C
3	Thanh Tri Section	100 km／hr	4	Type C or D
4	Resettlement Area	—	—	—

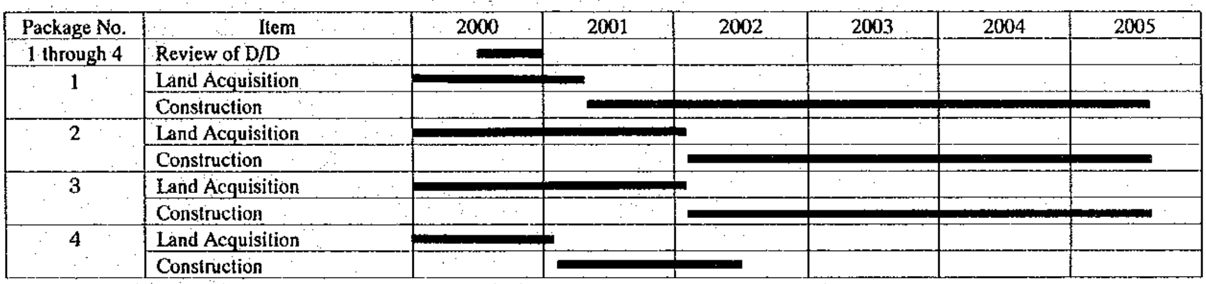
Note) *1: The Red River Bridge will be constructed with 6-lane width for future widening, even though 4 lanes will be operated initially.
*2: See Figure 1.

4. CONSTRUCTION COST

- February 2000 Prices
- 1 US$ = 14,000 Dong
- 1 Dong = 0.01 Yen

Pckage No.	Section	Road /Bridge Length	Construction Cost		
			F.C (Mill.¥)	L.C(Mill. D)	Total(Mill.¥)
1	Red River Bridge	3.1 km	12,059	714,437	19,203
2	Gia Lam Section	3.5 km	3,397	252,498	5,922
3	Thanh Tri Section	6.2 km	6,304	417,519	10,479
4	Resettlement Area	—	374	37,400	748
	TOTAL	12.8 km	22,134	1,421,854	36,352

5. IMPLEMENTATION SCHEDULE



6. ECONOMIC INDICATORS

Economic Indicators	Project as a whole
EIRR(%)	13.49
NPV(Million Dong)	594,800
B/C Ratio	1.18

Note) NPV and B/C ratio were calculated based on a discount ratio of 12% p.a.

7. RECOMMENDATIONS

1. The results of the Study indicate that the Project is technically sound (no serious technical difficulty is anticipated for the construction) and economically feasible. Taking into account the direct and enormous indirect benefits towards regional development other than the quantified savings in travel costs, the Project should be implemented at the earliest opportunity.

2. Delay of implementation would entail increasingly difficult land acquisition and resettlement due to the rapid development of the region, especially in Thanh Tri area. Arrangement of land acquisition and resettlement should commence immediately.

3. Proposed implementation schedule is to emphasize simultaneous commencement of services in all three construction sections, subject to due consideration on inevitable lead-time for land acquisition and resettlement, to optimize investment schedule.

4. A stage construction scheme such as widening from four lanes to six lanes in the future will entail immense technical difficulties when applied to Thanh Tri Bridge, Pahp Van – Cau Gie Interchange and National Highway No.5 Interchange. Thus it is recommended to provide a six-lane width in the initial stage to avoid this problem, even though only four lanes will be required initially.

OUTLINE OF THE STUDY

The Detailed Design of the Red River Bridge (Thanh Tri Bridge) Construction Project in the Socialist Republic of Viet Nam

- Study Period: April, 1999 - June, 2000
- Counterpart Agency: Project Management Unit Thang Long, Ministry of Transport

1. Background

Since an effective transport system is a basic requirement to achieve the future socio-economic development of the Hanoi region, a number of transport infrastructures improvement projects are either planned or under construction.

Many industrial zones are now either in operation or in the construction stage around Hanoi and along the major transport arteries. The traffic entering and originating from Hanoi will increase drastically in the near future.

In Hanoi, the total length of the road network is not sufficient for this increased usage. No adequate ring road system has been implemented, road widths are insufficient to allow for heavy vehicles and bridges are deteriorating.

2. Study Objectives

The Objectives of the Study were to carry out necessary engineering and environmental surveys, to complete a detailed design and to prepare draft tender documents of the Project, agreed on between the governments and to pursue technology transfer to the Government counterpart personnel in the course of the Study.

3. Study Area

The Study area covered Hanoi City and its vicinity where the influence of the Project will be expected.

4. Project Outline

4.1 Basic Policy

The detailed design and preparation of draft tender documents are carried out for the construction of required facilities which are proposed for the target year of 2010.

4.2 Content

The detailed design work for the construction of the Red River Bridge (Thanh Tri Bridge) and the Southern section of Hanoi Third Ring Road (SHTRR) were made within reference to the basic policy and study results as stated above.

(1) Future Traffic Volume

A forecast of future traffic volume based on present volume and the future socio-economic framework of the Study Area is shown in Table 1.

Table 1 Future Traffic Volume

Package No.		1	2	3
Section		Red River Bridge	Gia Lam Section	Thanh Tri Section
Road / Bridge Length		3.1 km	3.5 km	6.2 km
Traffic Volume In PCU / day	Year 2010	73,100	73,100	57,600 / 73,100 *
	Year 2020	111,700	111,700	86,400 / 111,700 *

Note) *: Traffic Volumes of Thanh Tri section indicate (section between NH1 and Phap Van Road) / (section between Phap Van Road and Thanh Tri Bridge).

(2) Design Speed, Number of Lanes and Typical Cross Sections

The number of lanes required was based on the expected traffic volume and traffic capacity. The road geometric standards, which includes design speed and cross-section structure, were determined in consideration of the characteristics of each Package and are given in Table 2.

Table 2 Number of Lanes and Typical Cross Sections

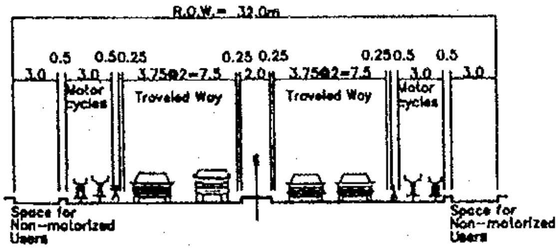
Package No.	Section	Design Speed	Number of Lanes	Typical Cross Section *2
1	Red River Bridge	100 km/hr	4 (6 *1)	Type A
2	Thanh Tri Section	100 km/hr	4	Type B or C
3	Gia Lam Section	100 km/hr	4	Type C or D

Note) *1: The Red River Bridge will be constructed with 6-lane width for future widening, even though 4 lanes will be initially operated as shown in Figure 1 - Type A.

*2: See Figure 1.

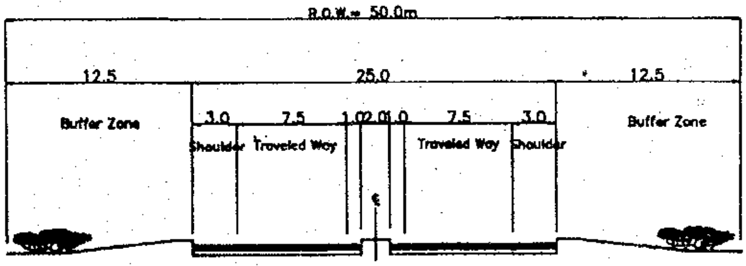
Type A

The Red River Bridge will be constructed with 6-lane width for future widening. However, the bridge will be initially operated as shown in Type A.



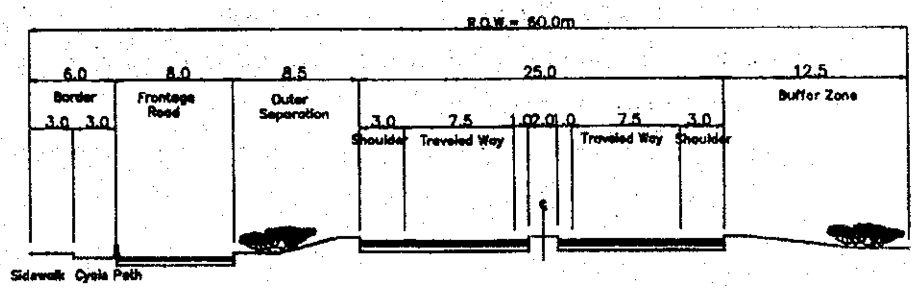
Motor Cycle Separation Scheme

Type B



Through Traveled Ways with Buffer Zone

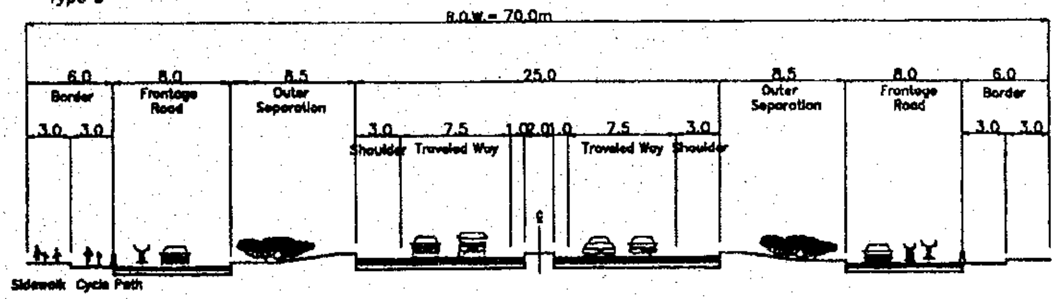
Type C



Through Traveled Ways with Frontage Road and Buffer Zone

Type D

Type D



Through Traveled Ways with Frontage Road on Both Sides

Figure 1 Typical Cross Sections

(3) Detailed Design, Cost Estimates and Preparation of Tender Documents

Based upon the highway's geometric standards the route selection was decided with efforts made to keep the influence on the human and natural environments to a minimum. At the same time, detailed design and construction planning were conducted. The project cost estimates and draft bidding documents were prepared based on these results.

(4) Outline of Project

- Package 1: Red River Bridge (Thanh Tri Bridge)

  This bridge which crosses the Red River has a total length of 3,084 m and consists of seven parts.

- Package 2: Gia Lam Section

  Package 2 is 3.5 km in length and the main works are the construction of:

  - Four lane throughways, frontage roads and border facilities;
  - One partial cloverleaf type interchange to connect SHTRR and National Highway No.5 including flyover bridge;
  - One half-diamond type interchange to connect the Red River Bridge and Gia Lam Dyke road; and
  - Three throughway bridges and two ramp way bridges by the prestressed concrete girder.

- Package 3: Thanh Tri Section

  Package 3 is 6.2 km in length and the main works are the construction of:

  - Four lane throughways, frontage roads and border facilities;
  - One single trumpet interchange to connect SHTRR and National Highway No.1 including viaduct;
  - One full-diamond type interchange to connect the Red River Bridge and Thanh Tri Dyke road;
  - One half-diamond type interchange to connect SHTRR and Nguyen Tam Trinh road;
  - One barrier type toll plaza; and
  - Four throughway bridges and three ramp way bridges by the prestressed concrete girder.

- Package 4: Construction of Resettlement Area

Main construction works in Package 4 are the construction of:

- Access roads and internal roads in the resettlement areas
- Water supply and drainage
- Public space and park

5. Project Costs

The estimated project costs for each Package at the exchange rates effective in February 2000 (1 US$ = 14,000 Dong) are shown in Table 3.

Table 3 Estimated Construction Cost in 2000 Prices

Package No.	Section	Road / Bridge Length	Construction Cost		
			Foreign Currency (Million Yen)	Local Currency (Million Dong)	Total (Million Yen)
1	Thanh Tri Bridge	3.1 km	12,059	714,437	19,203
2	Gia Lam Section	3.5 km	3,397	252,498	5,922
3	Thanh Tri Section	6.2 km	6,304	417,519	10,479
4	Resettlement	-	374	37,400	748
Total		12.8 km	22,134	1,421.854	36,352

6. Project Evaluation

6.1 Economic Analysis

The economic indicators for the project are shown in Table 4 and from these it can be seen that the Project is deemed economically feasible.

Table 4 Results of Economic Analysis

Economic Indicators	Project as a whole
EIRR (%)	13.49
NPV (Million Dong)	594,800
B/C Ratio	1.18

Note: NPV and B/C ratio were calculated based on a discount rate of 12 % p.a.

6.2 Financial Analysis

- Implementation of project by 100% of private sector is judged to be financially unfeasible since FIRR is less than 6%

- For implementation by the government, the fund combination with interest on the government loan and bank loan is not feasible because of the shortage of revenue, which cannot cover the repayment of principle and interest.

- There is a need to increase toll charge when the project is implemented by the fund resources with soft loan and government financing.

- Private concessionaire needs to participate in the project when the government cannot prepare the 20 % of project cost of without interest. In this case, the government needs to prepare soft loan of 70% of the project cost based on government guarantee to the soft loan provider.

- Implementation by private concessionaire is not easy to participate with 30% of equity of the project cost since FIRR is very low and not profitable. In this case, the Government needs to consider to give some considerations such as tax exemption or increase of toll fee.

6.3 Environmental Aspects

The construction of Thanh Tri Bridge and SHTRR will result overall in a large favorable impact on society and the economy of the people along the highway as well as the state. However, consideration must be given to minimize any adverse environmental effects and appropriate compensation should be made for land and properties affected by the Project.

7. Implementation Schedule

Project implementation time schedule is prepared as shown in Figure 2.

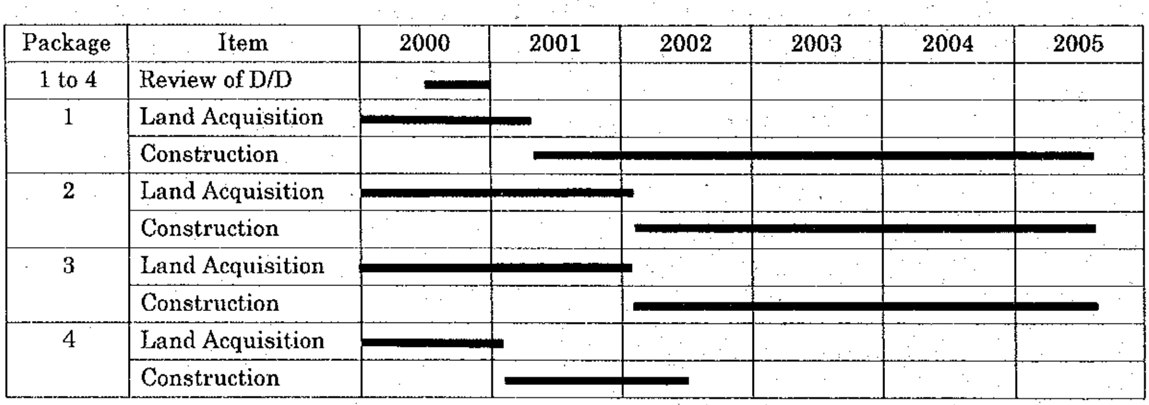


Figure 2 Project Implementation Schedule

As shown in Figure 2, the completion of the construction in all packages will be set at the same time of the middle of 2005 to attain the optimum investment schedule and to consider the time required for land acquisition and resettlement.

8. Recommendations

(1) Implementation of the Project

The results of the Study indicate that the Project is technically sound (no serious technical difficulties are anticipated for the construction) and also economically feasible. Taking into account the direct and enormous indirect benefits towards regional development other than the quantified savings in travel costs, the Project should be implemented at the earliest opportunity.

(2) Land Acquisition and Resettlement

Delay of implementation would entail increasingly difficult land acquisition and resettlement due to the rapid development of the region, especially in Thanh Tri area. Arrangement of land acquisition and resettlement should commence immediately.

(3) Project Implementation Schedule

Proposed implementation schedule is to emphasize simultaneous commencement of services in all three construction sections, subject to due consideration on inevitable lead-time for land acquisition and resettlement, to optimize investment schedule.

(4) Construction Scheme for the Future Widening

A stage construction scheme such as widening from four lanes to six lanes in the future will entail immense technical difficulties when applied to Thanh Tri Bridge, Pahp Van – Cau Gie Interchange and National Highway No.5 Interchange. Thus it is recommended to provide a six-lane width in the initial stage to avoid this problem, even though only four lanes will be required initially.

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THE RED RIVER BRIDGE (THANH TRI BRIDGE) CONSTRUCTION PROJECT
IN
THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT – Volume I: Summary

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1. INTRODUCTION

1.1 Project Background

The urban area in Hanoi, the capital city of the Socialist Republic of Viet Nam, has rapidly developed under the " Doi Moi " policy started from 1986. Hanoi is expected to keep on developing in future but traffic congestion is estimated to be one of the most serious problems. Measures to minimize traffic congestion is therefore a most important task but the existing road network is not sufficient. Accordingly it is important that the trunk road network be improved in the first place without further delay.

Hanoi is the main focus of human activities of the nation and the centre of commerce, finance, industry and transportation in the Red River Delta and Northern Focal Economic Area. The population of Hanoi was estimated at approximate 2.3 million people in 1994 and a sharp increase of population in Hanoi is expected based on the previous trends.. Increase of population is mainly caused by moving from the surrounding area due to imbalance of income and this trend is expected to continue in future. The present rate of increase in the central Hanoi is more than 3% a year

Under such increase of population and high economic growth, motorization that is from bicycle to motor bike and from motorbike to car is increasing dramatically and this will further increase in future.

National Highways No.1A, No.1B, No.3, No.5, No.6 and No.18 are the existing radial trunk roads in the Hanoi area but only Thang Long Bridge and Chuong Duong Bridge are available for crossing the Red River. Vehicles passing over bridges are concentrated at a part of the radial trunk roads and this causes traffic congestion. Furthermore, the mixed road usage by cars, motorbikes, bicycles and pedestrian also increases the problem.

As a result of the above-mentioned traffic conditions, Japan International Cooperation Agency (hereinafter referred as "JICA") has carried out the following projects in response to the request of the Government of the Socialist Republic of Viet Nam (hereinafter referred as "the Government"):

- The Study on Traffic System in Northern Area (1994)
- The Master Plan of Urban Transport for Hanoi City (1996)
- The Feasibility Study on Thanh Tri Bridge and Southern Section of Ring Road No.3 in Hanoi (1998)

In order to build the framework to solve the above-mentioned problems, the Master Plan of Urban Transport for Hanoi City was formulated by JICA in 1996. According to results of the study, the existing bridges over the Red River have not enough traffic capacity to correspond with the future increase in traffic volume. The concept of the Hanoi Third Ring Road (hereinafter referred to as "HTRR") to collect and distribute all incoming and outgoing traffic was therefore proposed.

Under such circumstances, the Government has decided to construct the most urgent section of HTRR that is the Southern Section of Ring Road No. 3 in Hanoi including Thanh Tri Bridge (hereinafter referred to as "the Project"). In the Feasibility Study on Thanh Tri Bridge and Southern Section of Ring Road No.3 in Hanoi, it was recommended the Project should be implemented as soon as possible.

Considering the background mentioned above, in July 1998 the Government requested the Government of Japan to implement the Project by ODA loans and in October 1998 they further requested to implement the detailed design of the Project by JICA. The Government of Japan sent an appraisal mission from the Japan Bank for International Cooperation (hereinafter referred as "JBIC") and gave a pledge on the ODA loans for the Project. The JICA preparatory study team for this detailed design was dispatched in December, 1998 and agreed the scope of work after confirmation of an exemption clause from responsibility of the result of detailed design.

1.2 Study Objective

The Objectives of the Study were to carry out necessary engineering and environmental surveys, to complete a detailed design and to prepare draft tender documents of the Project, agreed on between the governments and to pursue technology transfer to the Government counterpart personnel in the course of the Study.

1.3 Study Area

The Study area covered Hanoi City and its vicinity where the influence of the Project will be expected.

1.4 Scope of the Study and Work Flow

The Study was divided into four steps that were executed in a sequential manner:

- Step [1]: Review of the existing data. (April 1999)
- Step [2]: Data collection, natural condition survey, basic design and survey on environment. (April through June 1999)

- Step [3]: Detailed design, environmental impact assessment, construction planning, cost estimate, implementation planning and preparation of draft tender documents. (August 1999 through March 2000)
- Step [4]: Preparation and submission of final report. (May 2000)

The basic flow diagram, which identifies major work items to be carried out in each step, is indicated in Figure 1.1, and a work flow chart of the Study, which indicates also the approximate timing to carry out each work item and their relation, is shown in Figure 1.2.

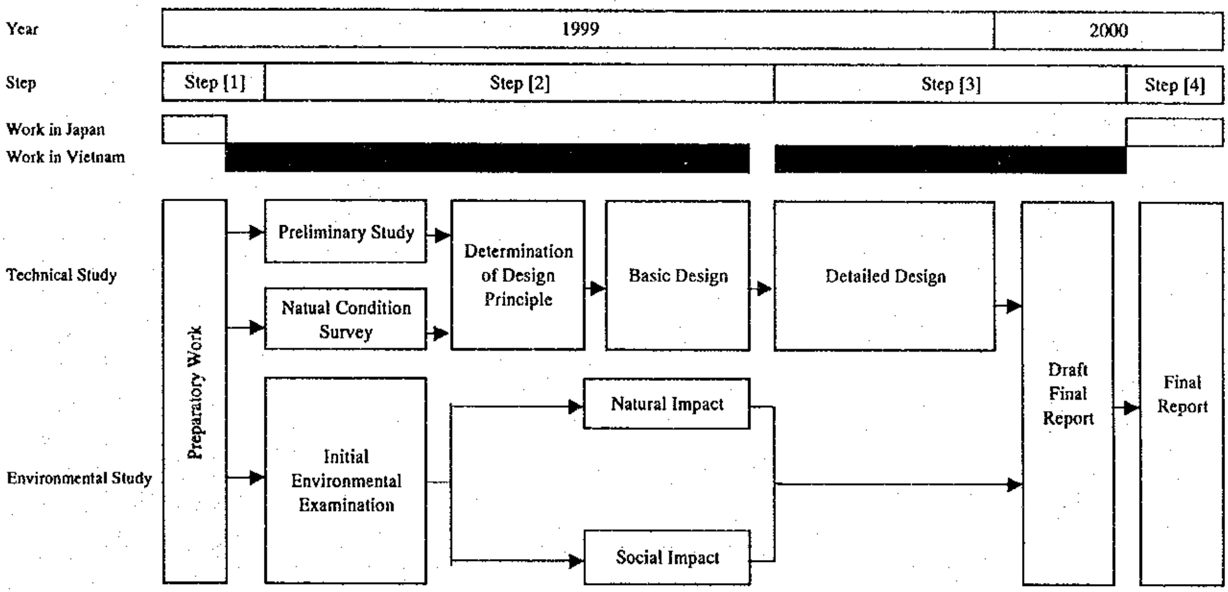
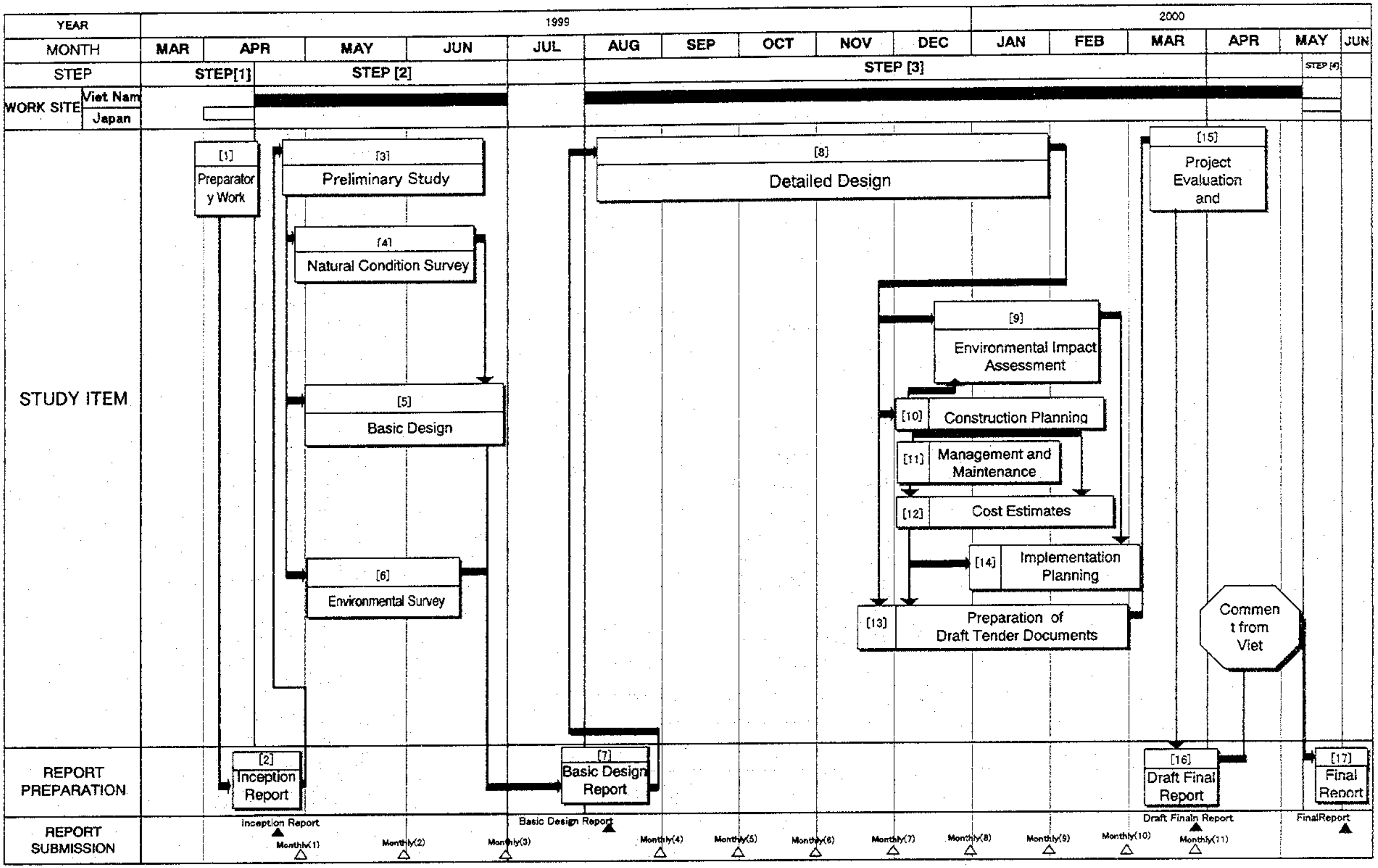


Figure 1.1 Basic Flow of the Study

1.5 Study Organization

The JICA Study Team carried out the Study closely collaborating with the Vietnamese counterpart personnel, who were arranged by the Government. A Steering Committee was set up by the Government and a Technical Evaluation and Examination Consultant was employed by JICA, for the duration of the Study. The study organization is shown in Figure 1.3.



△ : Report submission ▲ :Report submission and work shop

Figure 1.2 Work Flow Chart

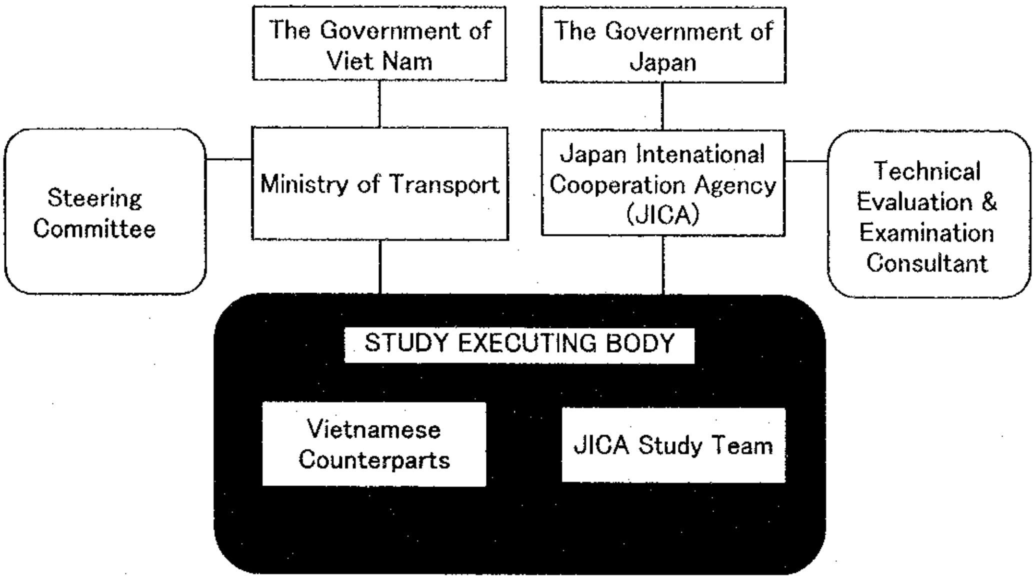


Figure 1.3 Study Organization

2. REVIEW OF THE FEASIBILITY STUDY

2.1 Transport Profile and Future Development Plans

(1) General Road Transport Condition in the Study Area

The transport network in the region consists of three modes; road, railway and inland waterway but road transport plays a very dominant role for both inter-regional and intra-regional transportation. Arterial roads run to and from Hanoi City in radial directions, connecting to all major cities in the country and to the surrounding provinces. An analysis on the general transport condition in the Study Area was carried out based on the existing data and this confirms :

- Increasing transport volume for both freight and passengers; and
- Road transport plays a dominant role in passenger transport, however inland water transport has a certain role in freight transport.

(2) Road Network

The network of National Highways is comprised of NH1, 2, 3, 5, 6, 18, 21, 32, etc. and they contribute significantly to land transportation in the Study Area.

The road network density in Viet Nam as a whole is 0.32 km per square km, and this is better than other Asian countries such as Thailand (0.20) and Malaysia (0.25). Although over 30 percent of the total length of national roads are paved with asphalt concrete, other roads are still in poor surface condition.

A complete and effective transport network is a basic need for the socio-economic development in Hanoi, but the total length of the road network in Hanoi is not sufficient for the present increasing usage. No ring road system has been implemented, road widths are insufficient to allow heavy vehicles, and bridges are deteriorating.

In 1996, JICA conducted a new Transport Master Plan named "The Study on Urban Transportation for Hanoi City in Vietnam, 1995" . The plan emphasized the need for a coordinated and integrated transport vision for Hanoi. It also highlighted the rapidly changing pace of development – reflected in urbanization and motorization – and the need to review and refine existing plans for transport.

The Ministry of Transport (MOT) and Transport and Urban Public Works Services (TUPWS) under Hanoi People's Committee have presented the proposed investment plan for the five years (1996-2000). Notwithstanding resettlement difficulties, it is planned to complete the First, Second and Third Ring Roads (including Thanh Tri Bridge). Five major radial roads into the City are also to be upgraded and several junctions are also targeted for improvement.

(2) Future Railway Network

Vietnamese National Railway (VNR) has links from Hanoi to major regional centres of the whole country such as Hai Phong (102 km), Ho Chi Minh City (1,726 km), Thai Nguyen (75 km), Lang Son (148 km) and Lao Cai (283 km). Also, there are 11 stations in Hanoi City.

The future railway development plan for the development target year 2020 was carried out by Vietnam National Railway Authority. The planned railway network consists of an outer-ring and a radial pattern from the center of Hanoi City.

(3) Regulating Reservoir and Park Development Plan in Yen So area

To control the flood in the northern area to Thanh Tri Dyke the Hanoi Planning Institute under the Hanoi People's Committee, is implementing a regulating Reservoir of 3.2 ha and a recreational park located at 800m along the Phap Van road from NH1. The target year of completion of the project is 2002.

2.2 Present Condition of Right-of-Way Acquisition

Present land use of the SHTRR roadside consists of paddy fields, ponds, industrial areas, monuments, factories, densely residential areas, historical churches and graveyards. Existing facilities crossing the SHTRR are local roads, footpaths, rivers, waterways including a drainage and an irrigation canal.

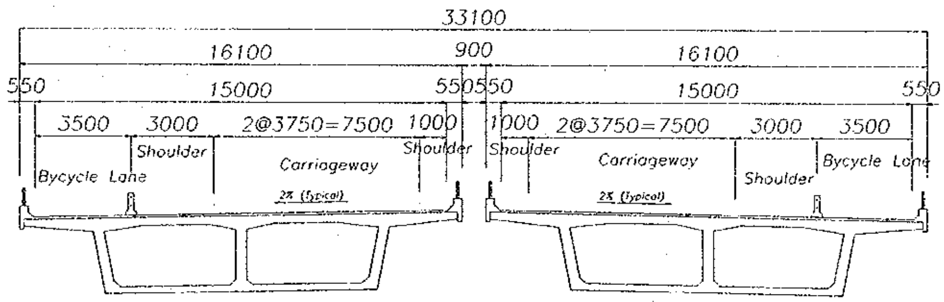
There are very many houses in the Thanh Tri area which is from National Highway No.1 to Thanh Tri Dyke and sufficient attention should be paid to the resettlement in this area. In the Red River area which is between Thanh Tri and Gia Lam Dykes there are few houses but the flood plain is used for cultivation and therefore land acquisition is still necessary for this area. Land use in the Gia Lam area from Gia Lam Dyke to National Highway No.5 is mostly rice field. There are some houses along National Highway No.5, so that a resettlement should be still considered in this area.

2.3 Construction Scheme for the Red River Bridge

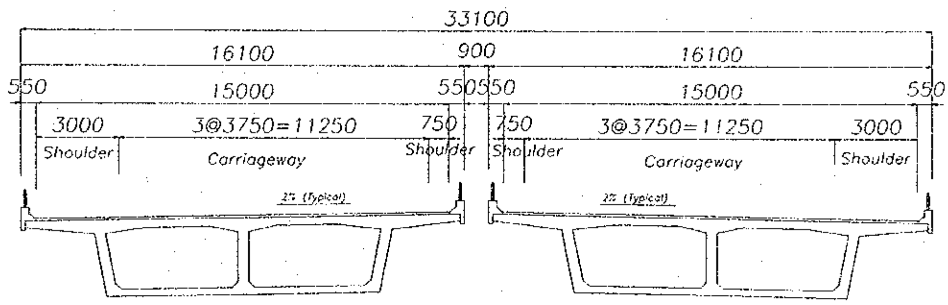
Regarding the construction scheme for the Red River Bridge, it was recommended to provide whole six-lane width in the initial and single construction stage.

The Detailed Design was carried out for the construction of required facilities which were proposed for the target year of 2010. Concerning the number of road lanes, the traffic capacity of 4-lane road will satisfy the requirements for the traffic volume in the year 2010, however in the year 2020, 6 lanes will be required as explained in Chapter 5. Therefore the same construction scheme as in the Feasibility Study was adopted in the Detailed Design.

Operation of road lanes was considered as shown in Figure 2.1.



(a) 4-lane Operation



(b) 6-lane Operation

Figure 2.1 Road Lane Operation of the Red River Bridge

3. PHYSICAL CONDITIONS SURVEY

3.1 Physical Conditions of the Study Area

(1) Topography

The topography is favorable throughout the entire Project Site. Flat land is spread out in the Red River delta with elevations at less than 10 m. The open area is mainly utilized for rice cultivation.

(2) Geology

Geologically, the flat terrain in the Red River delta area is of alluvium or diluvium formation of Holocene or Pleistocene Ages, composed of alluvial or diluvial soils of gravel, sand, loam, silt and clay.

(3) Climate

Annual average rainfall in Hanoi is about 1,700 mm of 80-85 % falls in the rainy season. The annual average number of rainy days is 140. Annual average temperature in Hanoi is 23.6 °C with its minimum of 4 °C and maximum 39.4 °C. Mean humidity is 82 %.

3.2 Topographic Survey

The topographic survey was conducted by dividing the area into 3 sections: the Thanh Tri side, the Red River Bridge section and the Gia Lam side.

(1) Mapping

The mappings were done by a total station system which used the "Auto Cad" program for mapping of topography.

The mapping area also included the surrounding areas of the existing bridges, the possible realigned approach roads and proposed resettlement areas. A scale of 1:500 or 1:1,000 was adapted for the mapping.

(2) Centerline Survey

The horizontal alignment of the proposed highway was determined in the geometric design and the plotting of the centerline on the ground has been carried out.

(3) Profile Survey

The profile survey along the proposed highway centerline was carried out. The profile survey was linked with the control points and the seven (7) GPS bench marks were set out.

Profiles were prepared to the following scales:

- Horizontal scale : 1:500 or 1:1,000
- Vertical scale : 1:100 or 1:200

(4) Cross-Section Survey

The elevations to prepare cross-sections along the centerline were calculated using a computer system. The scales of cross-sections were:

- Horizontal scale : 1:200
- Vertical scale : 1:200

(5) Riverbed Survey at Proposed Bridge Site

The cross-sections of the riverbed were taken at the proposed bridge site. In general, the survey locations were at the upstream and downstream paralleled to the proposed bridge centerline, approximately 100 m on either side. The scales of riverbed cross- sections were as follows:

- Horizontal scale : 1:200
- Vertical scale : 1:200

3.3 Soil and Material Investigations

(1) Purpose of the Investigations

The purpose of the investigations is to obtain data for the detailed design of bridges, embankment and pavement.

(2) Field Work and Laboratory Testing

The field work and laboratory testing were conducted by a local consulting firm. The JICA Study Team planned and supervised the investigations. Machine boring with standard penetration tests and statistic cone penetration test were conducted at 33 locations and 47 locations respectively. Pressuremeter tests (lateral loading test) were carried out at four boreholes in Red River Bridge section at depth of 5 m and 15 m from the ground level. Thin-wall tube samplings were also carried out for soft soils. Test pit samplings were made at possible sources of embankment materials, pavement materials and concrete aggregates. The laboratory testings were carried out for the collected samples.

(3) Alluvial Soils

The alluvial soils of the Red River delta are bright red-brown in color, composed of silt, about 20 - 25 % of clay and about 10 % of fine sand.

(4) Bearing Strata of Foundation Piles

Standard penetration tests were performed for the entire 50 m depth of each borehole at intervals of one (1) meter. Summary of bearing strata (N-value more than 50) for piled foundations are shown in Table 3.1.

Table 3.1 Summary of the Bearing Strata for Piled Foundations (N≧50)

Section	Location (Station)		Depth of Bearing Strata
Road section of Thanh Tri side	0-184.5	6+218	39m to 44m
Bridge section	6+218	9+302	32m to 54m
Road section of Gia Lam	9+302	12+832	36m to 42m

(5) Result of Pressure Test

The result of pressure test is shown in Table 3.2.

Table 3.2 Result of Pressuremeter Test

Name of Section	Borehole Number	Station	Ground Elevation at Borehole	Depth of the Test	Elevation of the Test	Modulus of Deformation (kPa)
Bridge Section	BH-B2	6+240	5.53	5.5	0.03	1,211
			5.53	15.5	-9.97	4,454
	BH-B8	7+470	0.02	5.5	-5.48	281
			0.02	15.5	-15.48	4,602
	BH-B9	7+730	-3.42	5.5	-8.92	697
			-3.42	15.5	-18.92	4,242
	BH-B14	8+720	5.05	5.5	-0.45	510
			5.05	15.5	-10.45	4,479

(6) Identified Soft Soil Layers

Soft Soil Layers were identified as shown in Table 3.3.

Table 3.3 Identified Soft Soil Layers

Section	Location (Station)		Depth of Soft Layer Top	Depth of Soft Layer Bottom
Road section of Thanh Tri side	0+000	6+214	0m to 17m	13m to 33m
Bridge section	6+214	9+401	0m to 3m	3m to 12m
Road section of Gia Lam side	9+401	12+388	0m	3m to 9m

(7) Borrow Materials

Many sand supplying companies are located along the shore of the Red River and its tributaries where the sand is pumped form the riverbed. Table 3.4 shows the test result of available sand.

Table 3.4 Test Result of Available Sand

Description	Lin Nam	Waterway Repair Co.	Duon Ha	Anh Dinh
Soil Symbol	SP	SW	SP/SM	SW
Maximum Dry Density	1.58 ~ 1.59t/m^3	1.80 ~ 1.81 t/m^3	1.63 ~ 1.65 t/m^3	1.84 t/m^3
Optimum Moisture Content	17.5 ~ 18.0%	12.0 ~ 12.2 %	15.2 ~ 15.7 %	10.0 %
CBR (Soaked)	9.0 ~ 20.0%	20.5 ~ 31.1 %	11.0 ~ 21.0 %	20.5 ~ 32.5 %

(8) Lime Stone Coarse Aggregate

Mieu Mon quarry and Kien Khe quarry are located about 45 km and 67 km in single trip distance from Thanh Tri area respectively. The sources and abrasion test result are shown in Table 3.5 together with daily production capacity.

Table 3.5 Lime Stone Coarse Aggregate

Quarry	Production Capacity	Los Angeles Abrasion
Mieu Mon Quarry in Ha Tay Province	100 ~ 200 m^3/day	17.3 ~ 19.7 %
Kien Khe Quarry in Ha Nam Province	100 m^3/day	17.6 ~ 20.0 %

(9) Summary of the Result of Settlement and Stability Analysis

The result of settlement and stability analysis is summarised in Table 3.6.

Table 3.6 Summary of Settlement and Stability Analysis

Soft Ground Treatment Strecech		Maximum Height of Embankment	Sand Drain		Plastic Board Drain		Minimum Safety Factor	Residual Settlement (cm)
from	to		Spacing (m)	Depth (m)	Spacing (m)	Depth (m)		
1+030	2+600	7.0	2.25	30.0	-	-	1.230	1.648
1+109	1+300	5.5	2.25	30.0	-	-	0.977	1.366
1+300	1+647	4.1	2.25	30.0	-	-	1.023	1. 024
2+600	3+300	11.0	2.00	26.2	-	-	1.203	0.001
3+330	6+214	9.0	-	-	1.50	16.0	1.201	0.935
9+298	10+920	8.0	-	-	1.50	18.0	1.290	0.018
10+920	12+060	9.0	-	-	1.50	16.0	1.215	0.031
12+060	12+868	7.0	1.75	16.7	1.50	16.7	1.211	0.001

In the above Table 3.6 its seen that the safety factor for sliding is less than 1.2 in the pond area stretch (Sta.1+109 ~ Sta.1+647). The construction of steel sheet piling is considered as a countermeasure for a shortage of safety factor.

3.4 Hydrological Analysis

(1) Objective and Scope

The objective of the hydrological analysis is to clarify the flow characteristics of the Red River at the project site and the interaction between the Red River Bridge (the Bridge) and the river. The analysis is focussed on the determination of high water level and flow rate at the design return period, the simulation of flow along the river nearby the Bridge, the verification of the impact of the Bridge to the river and dykes, and the calculation of the potential scour at the Bridge piers.

(2) The Red River

The main tributaries which flow through the north-west of Hanoi City are: the Da River, the Thao River, the Chay River, the Lo River and the Gam River. In the midstream, north of Hanoi City, the river is diverted to the west in the Day River and confluents from the east with the Thai Binh River through the Duong River. The river then flows eastwards through Hanoi City to the sea at Ba Lat. The river pattern is shown in Figure 3.1. The overall drainage basin occupies the area in Vietnam and also partly in Laos and China with a total drainage area of about 155,000 km^2.

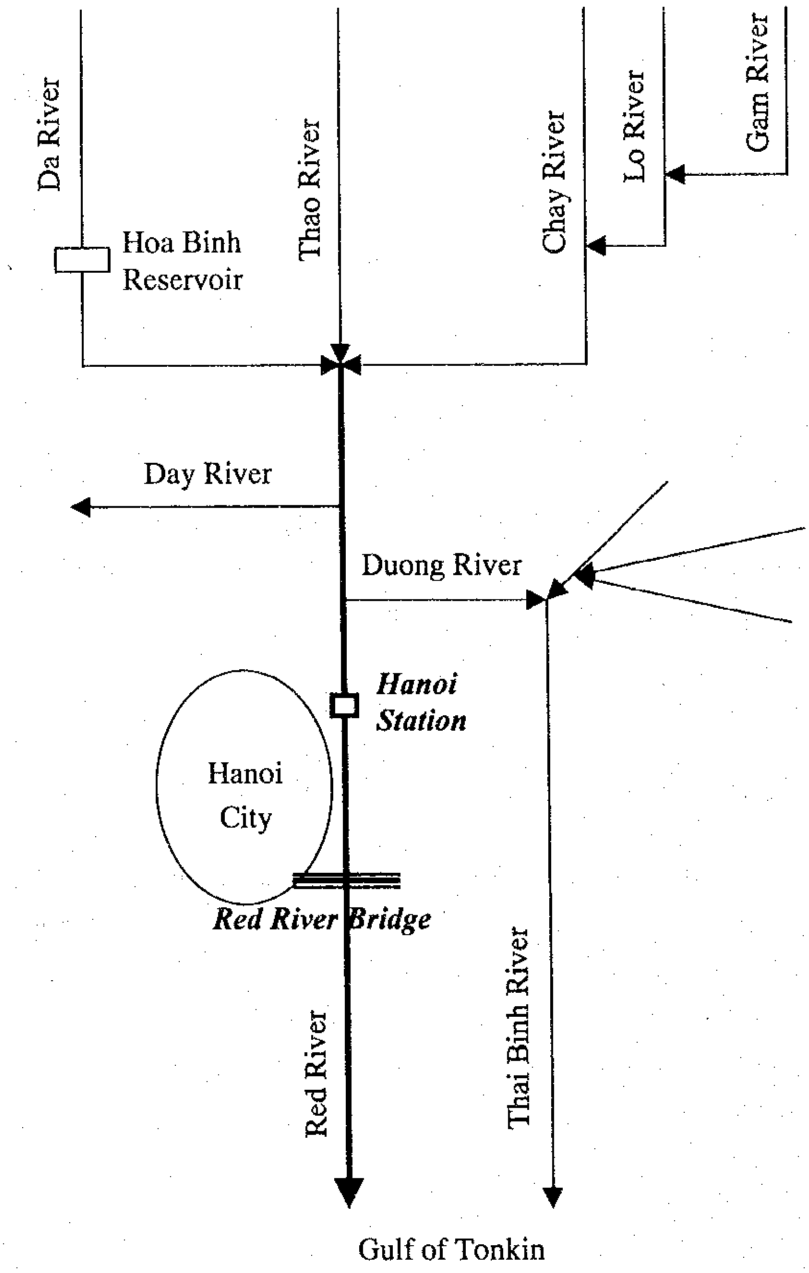


Figure 3.1 Flow Pattern of the Red River

Since 1988, the flow in the Da River has been regulated by the Hoa Binh reservoir. The portion of the regulated flow is reported to be more than 50% of the total flow in the Red River. In combination with the reservoir, a diversion at Day River has been also used to regulate the flow. The excess water during flood period has been diverted to this river. Therefore, flow in the Red River at Hanoi is at present regulated by the Hoa Binh reservoir and the diversion at Day River.

(3) River Survey

River surveys were conducted twice in 1999, during the dry period in June and flood period in August - September.

1) Survey in Dry Period

Cross section survey of the Red River was conducted in the upstream and downstream of the project site together with the measurement of velocity and water levels. Measured water levels are summarised in Table 3.7.

Table 3.7 Measured Water Levels in Dry Period

Date		Water Level (m)		
		Hanoi Station	Project Site	Diff.
12-Jun '99	morning	4.98	4.33	0.65
	afternoon	5.11	4.33	0.78
13-Jun '99	morning	5.24	4.56	0.68
	afternoon	5.26	4.56	0.70
14-Jun '99	morning	5.35	4.68	0.67
	afternoon	5.39	4.71	0.68
15-Jun '99	morning	5.41	4.75	0.66
	afternoon	5.45	4.77	0.68
Average		5.27	4.59	0.69

2) Survey in Flood Period

The survey was conducted again during August - September 1999. The range of the survey was from Hanoi Station in the upstream to Khuyen Luong Port in the downstream of the project site.

The information needed from this survey was basically same as those in the dry period. However, all data were taken when water level rose up to the flood plain in order to obtain the additional information during flood period for the hydraulic simulation.

The survey was conducted for a total of 28 river cross-sections as shown in Figure 3.2. The spacing within 1 km in the upstream and downstream of the project site was 200 m, while that out of this range was about 500 m.

A summary of the measured water levels and velocities at Key locations are shown in Table 3.8.

Table 3.8 Measured Water Level and Velocity in Flood Period

Section	Location	Date	Average Water Level (m)	Average Velocity (m/s)	Max. Section Velocity (m/s)
T-1	Hanoi Station	Sept. 1 '99	10.25	1.14	1.43
		Sept. 2 '99	10.63	1.26	1.57
T-12	1 km upstream of Project Site	Sept. 1 '99	9.55	1.62	2.38
		Sept. 2 '99	9.89	1.78	2.54
T-17	Project Site	Sept. 1 '99	9.50	1.67	1.81
		Sept. 2 '99	9.83	2.23	2.29
T-27	Khuyen Luong Port	Sept. 1 '99	9.22	1.53	2.04
		Sept. 2 '99	9.53	1.58	2.18
Water level difference (Hanoi Sta. - Project Site)		Sept. 1 '99	0.75		
		Sept. 2 '99	0.80		
		Average	0.78		

(4) Fluctuation of the Riverbed at Project Site

In order to verify the riverbed change at the project site, the measured cross-section at the project site in this Study is compared with those measured in the Feasibility Study. Due to the short period of measurement, any conclusion on the long-term change cannot be drawn from these data.

However, the figure shows no significant change of the riverbed profile. A variation of about 3 m were found during those 2 years after 2 moderate floods. This magnitude is about same as the riverbed change at Hanoi Station as well.

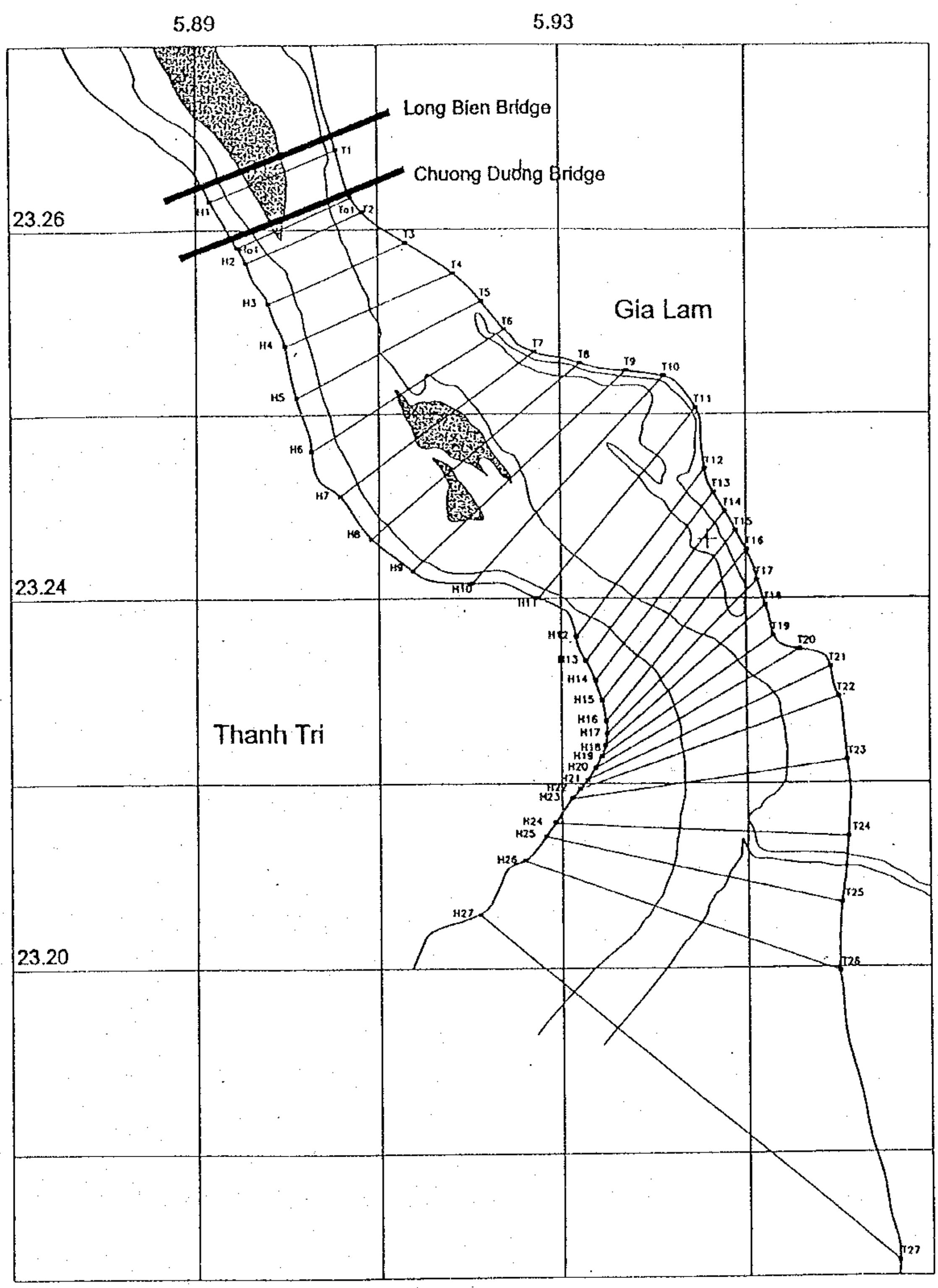


Figure 3.2 Locations of the Cross-Section in the River Survey in 1999 (Flood Period)

(5) Frequency Analysis of Flood Water Level

The frequency of the recorded data at Hanoi Station was analyzed by using the standard Gumbel method for the maximum water level. The analysis was divided into 3 periods, the period from 1945 to 1987, from 1988 to 1998 and the whole period from 1945 to 1988 by considering the flow change after the operation of the Hoa Binh reservoir and the diversion of discharge to the Day River in 1988. Result of the analysis is shown in Table 3.9.

Table 3.9 Maximum Water Level at Each Return Period at Hanoi Station

Return Period (year)	Max. Water Level (m, msl)		
	1945 - 1987	1988 - 1998	1945 - 1998
20	12.94	13.13	12.87
100	14.32	14.55	14.20

Results of the river surveys and hydraulic simulation revealed the water level difference (h) between Hanoi Station and the project site as follows:

In June 1999,	h	=	0.69 m
In August 1999,	h	=	0.75 m
From simulation,	h	=	0.71 - 0.79 m
	Average h	=	0.72 m

The range of design water level (HWL) at the project site will be obtained by taking into consideration of the water surface gradient of 0.72 m.

20-year	:	HWL	=	12.15 - 12.41 m
100-year	:	HWL	=	13.48 - 13.83 m

Thus, the proposed water level at 20 year return period in the design is 12.50 m. This is the same as the value recommended by the Ministry of Transport. The HWL at 100-year return period should be about 13.90 m.

(6) Design Flood Discharge

The rating curve (H-Q curve) is formulated, the design discharge is calculated from this rating curve. By considering this curve in combination with the rating curve from Hanoi

Station and the UNDP report, the proposed design flood discharges are determined as shown in Table 3.10.

Table 3.10 Design Flood Discharge

Return Period	Design Flood Discharge (m^3/s)	Remark
20 year	17,900	
100 year	22,200	equivalent to flood in 1971 (for reference only)

(7) Hydraulic Simulation

Hydraulic simulation is divided into 3 parts as follows:

i. Simulation of hydrograph along the river from Hanoi Station to the project site using an unsteady flow program;

ii. Simulation of surface-water velocity along the river from Hanoi Station to Khuyen Luong Port without and with the existence of bridge piers using a two-dimensional flow program; and

iii. Calculation of scour at the design bridge piers using a scour computation program.

From the result of hydraulic simulation and calculations it is concluded that:

- Historical records of riverbed cross-section (river course and river plain) nearby the project site show no significant change during 1981 - 1998. The river course in this part is stable.

- The simulated water level at the project site during flood in 1971, 20-year return period and maximum regulated flow are lower than the height of dyke in Hanoi and Gia Lam.

- The surface-water velocity at and nearby the project site varies from 1.0 - 2.0 m/s and the maximum value is found at the location behind the pier Nos. 14 and 15.

- Maximum scour depth at a bridge pier is about 8.50 m at 20-year return period.

- The bridge piers may have the impact to the flow within the distance of about 17 m in the upstream and downstream of the bridge piers.

- It is recommended that riverbed armor will be provided under the Bridge to protect from the flow disturbance and erosion.

- It is also recommended that monitoring of the flow and river morphology change should be conducted after the completion of the Bridge.

4. Design Standard

4.1 Design Standard of the Proposed Road

Highway design criteria were established based on Vietnamese standards with reference to Japanese standard and design policy of Highway and Streets in USA (AASHTO). In addition, the design criteria were considered based on the concept of the feasibility study by JICA. Tables 4.1 through 4.5 show the design criteria for the throughway, frontage road and ramp-way.

Table 4.1 Summary of Design Criteria for Throughway

Item	Unit	Adopted Value
Class Road		Class I-II
Design Speed	Km/h	100
Cross Section Elements	Lanes	
Number of Lanes	m	4
Lane Width	m	3.75
Median Width	m	2.0
Inner Shoulder Width	m	1.0
Outer Shoulder Width	m	3.0
Cross-fall of Carriage-way	%	2.0
Cross-fall of Shoulder	%	2.0
Maximum Super-elevation	%	7.0
Horizontal Alignment		
Minimum Radius	m	450
Length of transition curve for minimum radius	m	100
Minimum radius without super-elevation	m	3,000
Vertical Alignment		
Maximum Grade	%	4
Minimum Radius of Vertical Curve		
Crest	m	6,000
Sag	m	3,000
Minimum Stopping Sight Distance	m	160
Minimum Passing Sight Distance	m	700
Vertical Clearance	m	4.75

Table 4.2 Summary of Design Criteria for Frontage Road

Item	Unit	Adopted Value
Class Road		Class IV
Design Speed	Km/h	60
Cross Section Elements		
Number of Lanes	Lanes	2
Lane Width	m	3.5
Median	m	-
Inner Shoulder Width	m	0.5
Outer Shoulder Width	m	0.5
Crossfall of Carriageway	%	2
Crossfall of Shoulder	%	2
Maximum Super-elevation	%	6
Horizontal Alignment		
Minimum Radius	m	150 (125)
Critical curve radius with transition curve	m	500
Minimum curve radius without super-elevation	m	500
Vertical Alignment		
Maximum Grade	%	6
Minimum Radius of Vertical Curve		
Crest	m	1,500
Sag	m	1,000
Minimum Stopping Sight Distance	m	75
Minimum Passing Sight Distance	m	350
Vertical Clearance	m	4.5

Table 4.3 Throughway Standard in the Vicinity of Interchange

Item	Unit	Requirement
Design Speed of Main Road	Km/h	100
Minimum Radius	m	1,500 (* 1,000)
Minimum Vertical Curve (Crest)	m	25,000 (* 15,000)
Minimum Vertical Curve (Sag)	m	12,000 (* 8,000)
Maximum Gradient	%	2 (* 3)

Note : (*) is a special case

Table 4.4 Summary of Design Criteria for Interchange Ramps (Two-lane , one-way)

Item	Unit	Adopted Value
Design Speed	Km/h	40
Cross Section Elements		
Number of Lanes	Lanes	2
Lane Width	m	3.5
Median	m	-
Inner Shoulder Width	m	1.0
Outer Shoulder Width	m	1.0
Protective Shoulder	m	0.75
Crossfall of Carriageway	%	2.0
Crossfall of Shoulder	%	2.0
Maximum Super-elevation	%	10
Composite gradient	%	11
Horizontal Alignment		
Minimum Radius	m	50.0
Critical curve radius with transition curve	m	140
Minimum curve radius without super-elevation	m	600
Vertical Alignment		
Maximum Grade	%	6.0
Minimum Radius of Vertical Curve		
Crest	m	900
Sag	m	900
Minimum Stopping Sight Distance	m	40
Length of Deceleration lane		
Two lane	m	130
Length of Acceleration lane		
Two lane	m	260
Exit Angle		
Two lane		1/25
Entrance Angle		
Two lane		1/40
Vertical Clearance	m	4.75

Table 4.5 Summary of Design Criteria for Interchange Ramps (One-lane, one-way)

Item	Unit	Adopted Value
Design Speed	Km/h	40
Cross Section Elements		
Number of Lanes	Lanes	1
Lane Width	m	3.5
Median	m	-
(Non-motorcycle Width)	m	(3.0)
Inner Shoulder Width	m	2.5
Outer Shoulder Width	m	1.0
Protective Shoulder	m	0.75
Crossfall of Carriageway	%	2.0
Crossfall of Shoulder	%	2.0
Maximum Super-elevation	%	10
Composite gradient	%	11
Horizontal Alignment		
Minimum Radius	m	50.0
Critical curve radius with transition	m	140
Minimum radius without super-elevation	m	600
Vertical Alignment		
Maximum Grade	%	6.0
Minimum Radius of Vertical Curve		
Crest	m	900
Sag	m	900
Minimum Stopping Sight Distance	m	40
Vertical Clearance	m	4.5
Length of Deceleration Lane		
One lane	m	90
Length of Acceleration		
One lane	m	180
Taper Length		
One lane	m	60
Exit Angle		
One lane		1/25
Entrance Angle		
One lane		1/40
Vertical Clearance	m	4.75

4.2 Bridge Design Standard

(1) Design Codes

AASHTO Standard Specifications for Highway Bridges, 16th edition, 1996 (herein after called "AASHTO standard") was adopted for design of all structures in this project. Vessel collision force is calculated in accordance with the provisions specified in AASHTO LRFD Bridge Design Specifications, 2nd edition, 1998 (hereinafter called "AASHTO LRFD specification"). The AASHTO standard was supplemented and / or modified as appropriate by Vietnamese Bridge Design Codes 22TCN 018-79 (herein after called "VNBDC") and Japanese Specifications for Highway Bridges, the 1996 edition (hereinafter called "JSHB").

(2) Loads

1) Live Load

125% of the standard AASHTO HS20-44 truck or lane loads was used in the design. Where maximum stresses are produced in any members by loading a number of traffic lanes simultaneously, the load intensity was reduced in accordance with AASHTO Article 3.12.1 in view of the impossibility of coincident maximum loading.

H30 and XB80 live loads specified in VNBDC are also considered.

2) Seismic Load

Seismic acceleration coefficient of 0.17 was considered as recommended by the Institute of Geophysics of Vietnam National Center for Natural Science and Technology.

3) Vessel Collision Force

The maximum ship and the maximum barge to be considered in the design are 1,242 DWT and 1,712 tons of water displacement, respectively. The collision forces were calculated in accordance with AASHTO LRFD specification. Calculated maximum collision force is 631tf.

4) Other Loads

Other loads are calculated in accordance with AASHTO standard in general.

5) Combinations of Loads

The combinations of loads and the load factors are in accordance with Section 3, Part B of AASHTO standard

(3) Flood and Navigation Clearance

The navigation clearance will be 10 meters above the high water level (HWL), which has been determined to be 12.5 meters for a return period of 20 years (Figure 4.1).

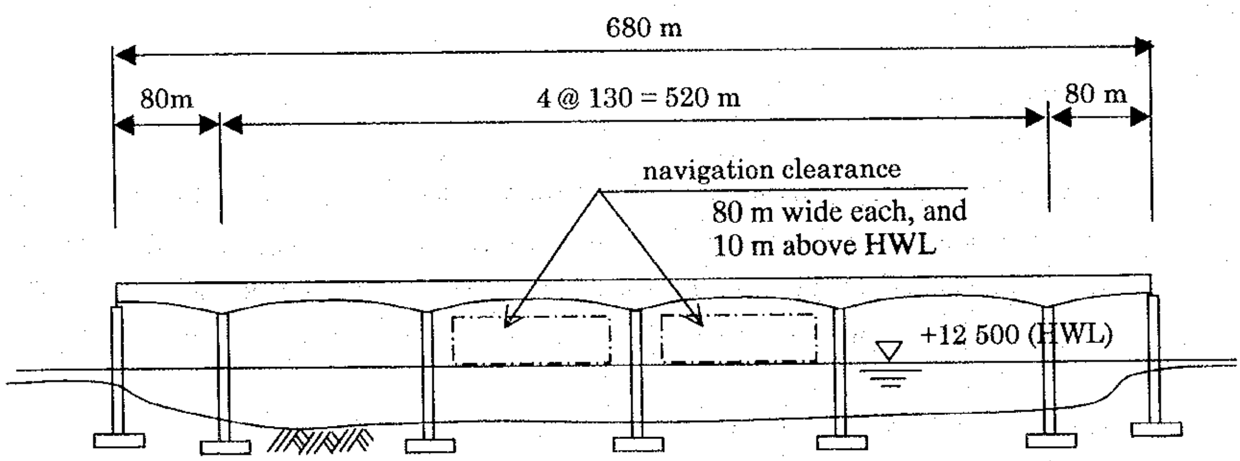


Figure 4.1 Navigation Clearance

The flood clearance has been determined based on Article 1.27 of VNBDC.

(4) Materials and Strengths

Concrete strengths for primary structures are 400 kgf/cm^2 and 290 kgf/cm^2 for prestressed concrete and reinforced concrete, respectively. Reinforcing bar and prestressing tendon will comply with the requirements of AASHTO, ASTM, JIS or equivalent.

The allowable stresses were determined in accordance with AASHTO standard.

5. DETAILED DESIGN OF HIGHWAY

5.1 Traffic Capacity and Required Number of Lanes

The concept and methodology used for the traffic capacity analysis of the throughway, ramp-way and frontage road are based on the "Highway Capacity Manual of Highway Research Board, U.S.A.". However, some adjustment is made to reflect local conditions base on the results of studies undertaken by the "Highway Research Board, Japan (Japanese Standard)", since much resemblance is found in type and size of vehicles and in operating conditions, in Vietnam and Japan.

Table 5.1 shows future traffic volume and traffic capacity of the proposed road.

Table 5.1 Future Traffic Volume / Capacity of the Proposed Road

Section	Future Traffic Volume and Capacity (PCU/day)	
	2010	2020
Throughway (two way)	73,200 (75,600 - 4 lanes)	111,700 (113,400 - 6 lanes)
Thanh Tri Bridge (two way)	73,200 (75,600 - 4 lanes)	111,700 (113,400 - 6 lanes)
Frontage Road (2 lanes, One way)	17,000 (30,900)	22,000 (30,900)

Note: - Value in brackets ( ) means design traffic capacity.

- Traffic volume of the frontage road was forecasted at the Phan Van road.

5.2 Design for Throughway/Frontage Road

For the detail design, the urban plan (Socio-Economic Master Plan of Hanoi City by the Year 2010 and 2020) and the future railway plan were discussed with the related agencies such the Hanoi People's Committee and the Vietnam Railway Association. These plans were then reflected in the setting of the horizontal and vertical alignments.

(1) Alignment Design

Figure 5.1 shows the out line of the horizontal alignment indicated land use and the existing facilities in the vicinity of the project area. Especially, for the detail design, in addition to paying attention to the highway standard mentioned in Chapter 4.1, the following conditions are carefully considered.

(Horizontal Alignment)

- To minimize the number of houses affected and the number of inhabitants requiring to be resettled. The alignment was therefore decided so as to utilize the existing road and so as to avoid the densely populated residential areas as far as possible.

- To minimize social and social /economic isolation in dense residential areas. This means to avoid severance due to communities divided by the project road.
- To avoid the disturbance to other projects such as industrial areas both under construction and planning, Yen So Reservoir area, planned chemical factory, cement concrete factory, Pagoda, Linh Nam monument, graveyards, etc.
- To maintain the function and accelerate the development of the existing railways and the accessibility of existing roads which crossing the project road. For this reason, their future plans were considered.

(Vertical Alignment)

- Elevation of the road surface should be higher than the required probable flood water level in the project area.
- To maintain the function and accelerate the development of the existing railways and roads crossing the project road, their future plan and their vertical / horizontal clearance were considered.
- To install underpass facilities to avoid hindering the development of the existing railways and the accessibility of existing roads which crossing the project road. This also avoided adverse effects of community dispruptionn in adjacent areas.
- To lower embankment height as much as possible from the point of view of the stability and settlement of the embankment.

1) Horizontal Alignment Setting

Horizontal alignment consists of straight lines, circular-curves and clothoid-curves. The highway standard decided in Chapter 4.1 is applied to the decision of geometric structure for the horizontal alignment.

2) Vertical and Horizontal Clearance

Vertical alignment design is especially influenced by the vertical and horizontal clearance the rivers and the existing facilities (i.e. roads and railways). In the vertical alignment design, cClearance from the following existing / planned facilities were secured

Table 5.2 Clearance of Existing / Planned Facilities

Facilities	Horizontal Clearance (m)	Vertical Clearance (m)
Expressway	-	4.75
Urban arterial road	-	4.50
Local road	-	3.50
Pedestrian road	3.00	2.50
Rail way	25.00	6.80 (5.80)

(2) Alignment Design on the Natural Condition

1) Flood Water

Except for the residential areas, the project area is often is flooded due to the low elevation and high ground water level. The formation level of the throughway and the other roads should be higher that of the high water level at 100 year return period and that of the high water level at 25 year return period respectively. At the Thanh Tri Side, minimum design formation level including freeboard of the throughway and the other roads are 7.0 m and 6.0 m respectively as shown in Table 5.3. At the Gia Lam side, minimum design formation level including freeboard of the throughway and the other roads are 7.0 m and 5.5 m respectively as shown in Table 5.4.

Table 5.3 Minimum Design Formation Level at Thanh Tri Side

Name of road	Probable flood level (m)	Freeboard (m)	Design Minimum Formation Level (m)
Throughway	6.00	1.00	7.00
Interchange ramp	5.50	0.50	6.00
Frontage road	5.50	0.50	6.00
Urban road	5.50	0.50	6.00

Table 5.4 Minimum Design Formation Level at Gia Lam Side

Name of road	Probable flood level (m)	Freeboard (m)	Design Minimum Formation Level (m)
Throughway	5.50	1.00	7.00
Interchange ramp	5.00	0.50	5.50
Frontage road	5.00	0.50	5.50
Urban road	5.00	0.50	5.50

2) Soft Ground Area

All of the project area is in the soft ground zone. In order to decide vertical alignment, the critical embankment heights at each section of the project road were analyzed to prevent embankment slide, based on the soil survey and the selection of the countermeasures (sand drain and plastic board drain) decided by the project.

Table 5.5 Result of Soft Ground Stabilization Analysis
(Throughway and Frontage road)

Geological sections	From / To	Critical embankment height (m)	Comprehensive Countermeasure: Sand drain Interval (m)	Sand drain Depth (m)	Sand drain Fs Safety Factor	Plastic board drain Interval (m)	Plastic board drain Depth (m)	Plastic board drain Fs Safety Factor	Residual settlement 450 days
T-1-a	1+030 2+600	7.0 (with frontages roads)	2.25	30.0	1.230				1.648
T-1-b	2+600 3+300	11.0 (with frontage roads)	2.00	26.2	1.203				0.001
T-2	3+300 6+214	9.0 (with frontage roads)				1.50	16.0	1.201	0.935
G-1-a	9+298 10+920	8.0 (with one frontage road)				1.50	18.0	1.290	0.018
G-1-b	10+920 12+060	9.0				1.50	16.0	1.215	0.031
G2	12+060 12+868	7.0				1.50	16.7	1.211	0.001
G2	12+060 12+868	* 9.0	1.75	16.7	1.202				0.000

Note: * : Critical embankment height with the counterweight embankment (h=2.3; EL=3.7m, w=14m)

Table 5.6 Result of Soft Ground Treatment Analysis
(Ramp-way)

Geological sections	From / To	Critical embankment height (m)	Comprehensive Countermeasure: Sand drain Interval (m)	Sand drain Depth (m)	Sand drain Fs Safety Factor	Plastic board drain Interval (m)	Plastic board drain Depth (m)	Plastic board drain Fs Safety Factor	Residual settlement 450 days
T-1-a	1+030 2+600	8.0	2.50	30.0	1.215				1.462
G-1-a	9+298 10+920	9.0 8.0				1.25 1.50	18.0 18.0	1.209 1.254	0.000 0.003
G2	12+060 12+868	8.0 7.0				1.50	16.7	1.211	0.000
G2	12+060 12+868	* 8.0				1.00	16.7	1.208	0.000

Note: * : Critical embankment height with the counterweight embankment (h=2.3; EL=3.7m, w=14m)

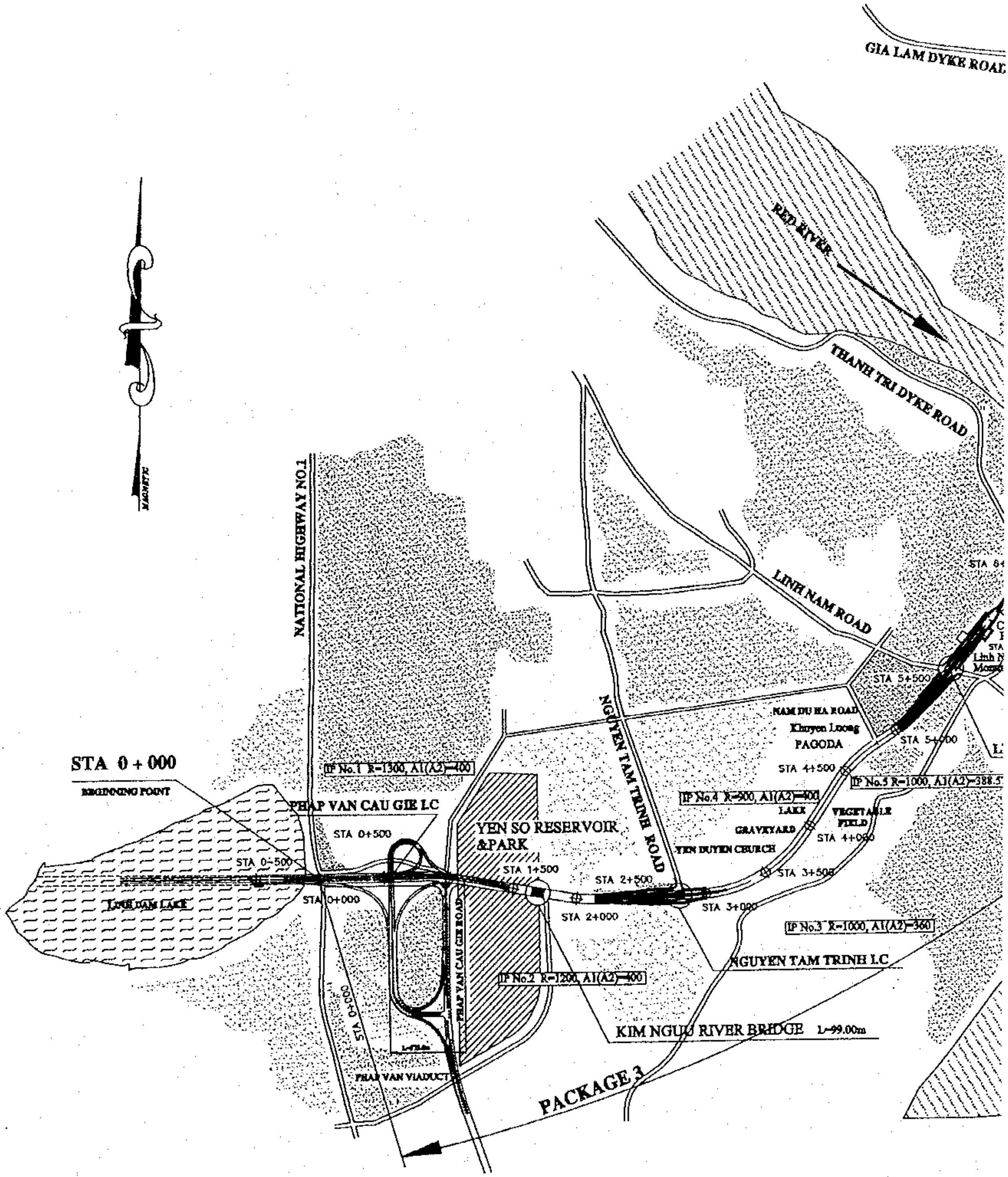


Figure 5.1 Project Area (1)

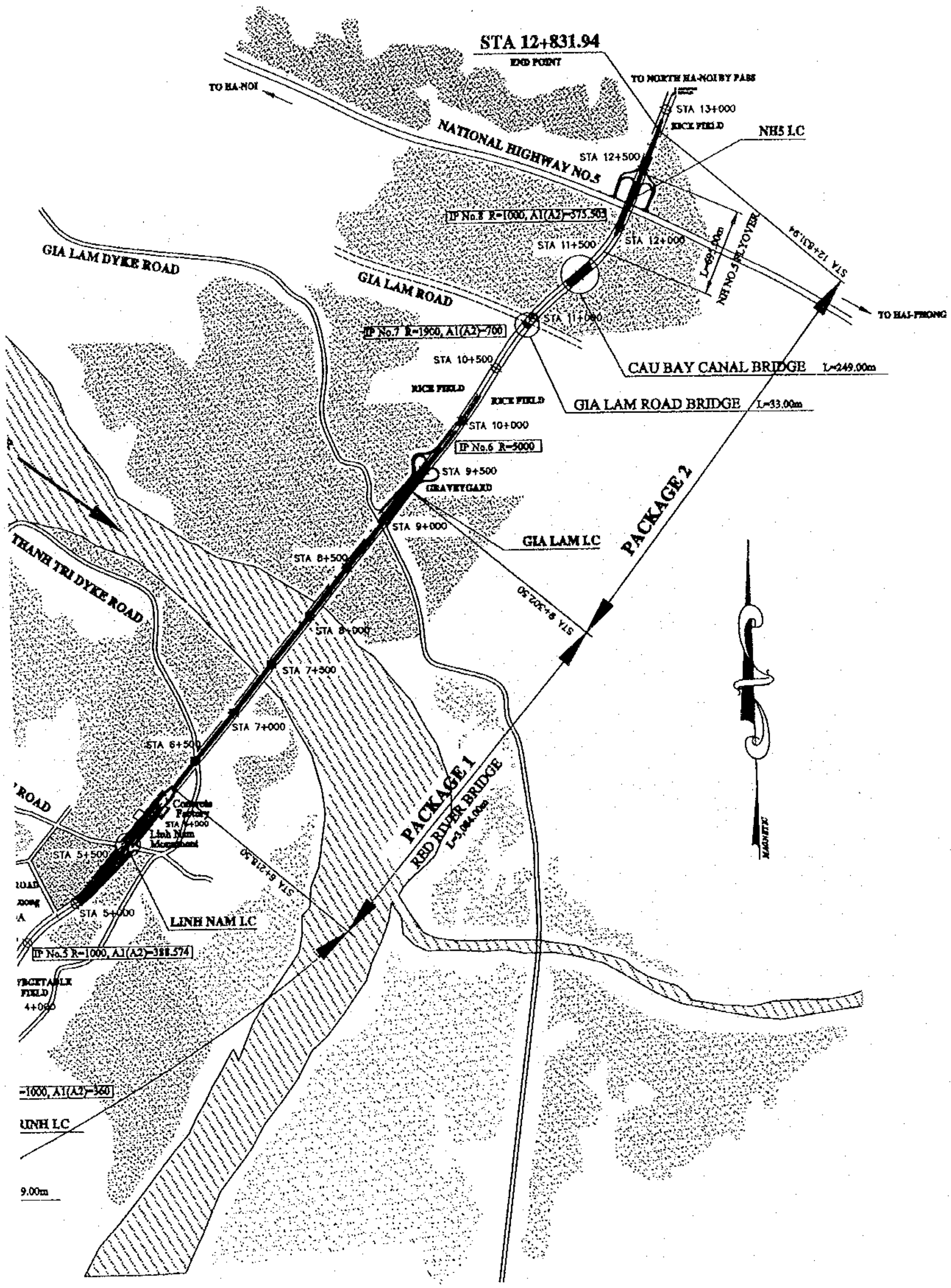


Figure 5.2 Project Area (2)

5.3 Interchange Design

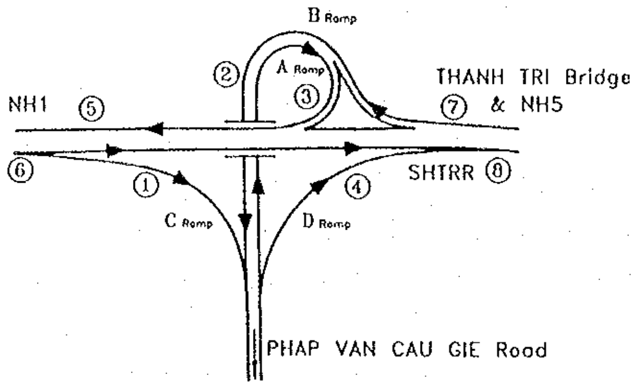
(1) Location / Type / Function of Interchange

The location and the type of the interchanges on the project road were decided from the social-economic and technical point. In addition these are decided based on the consultation with the PMU Thang Long; Hanoi Chief Architect Office; and Hanoi People's Committee. Table 5.7 indicates location and function of the each interchange and Table 5.8 shows each interchange type.

Table 5.7 List of Interchanges (I.C)

I.C Name	I.C Type	Linking Road	Function
Phap Van Cau Gie STA 0+550	Single Trumpet	Phap Van Cau Gie Road	Access from Phap Van Cau Gie road to the project road and access from the project road to Phap Van Cau Gie road. Access from NH1 to the project road and access from the project road to NH1.
Nguyen Tam Trinh STA 2+800	Half Diamond	Nguyen Tam Trinh Road	Access between Nguyen Tan Trinh road and the project road. On-ramp A access to NH1 or Phap Van Cau Gie road, and off-ramp B access to Nguyen Tan Trinh road.
Linh Nam STA 5+630	Full Diamond	Linh Nam Road	Access between Linh Nam road and the project road. On/off-ramp A,B access between NH1or Phap Van Cau Gie road and Linh Nam road. On/off-ramp C,D access between Linh Nam road and Tan Trinh bridge with bicycle lane for community service..
Gia Lam Dyke STA 8+958	Half Diamond	Gia Lam Dyke Road	Access between Gia Lam Dyke road and Gia Lam side. On-ramp A access to Thanh Tri bridge and off-ramp B access from Thanh Tri bridge to Gia Lam side with bicycle lane for community service.
NH5 STA12+179. 59	Half Clover Leaf	NH 5	Access between NH5 and the project road. On/off-ramp A,B access between Thanh Tri bridge and NH5. On/off-ramp C,D access between Duong bridge.

Table 5.8 Interchange Type

<table>
<tr><th>Interchange Name</th><th>Configuration</th></tr>
<tr><td>Phap Van Cau Gie</td><td>
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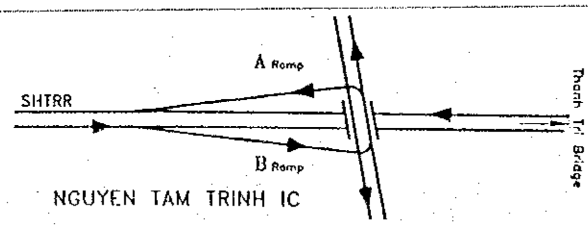
<tr><td>Nguyen Tam Trinh</td><td>
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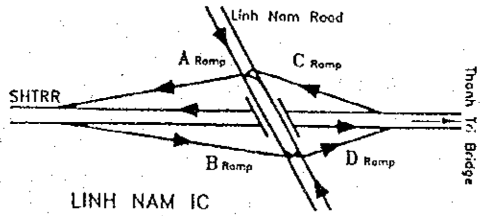
<tr><td>Linh Nam</td><td>
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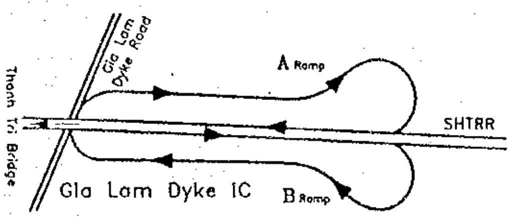
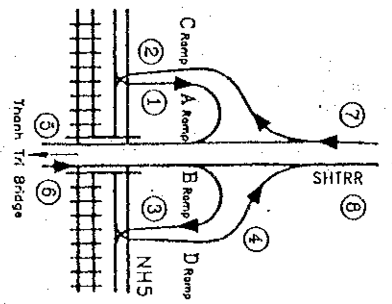
<tr><td>Gia Lam</td><td>
</td></tr>
<tr><td>NH5</td><td>
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</table>

5.4 Cross Section

Facility which make up the road cross section (and their width) are given in the Chapter 4, 4 .1, and the traffic analysis is given in Chapter 5, 5.1. The components of the cross section for the throughway, frontage road and ramp-ways applied for the project road are as follows:

Table 5.9 Cross Section Component for the Throughway Type

(unit: m)

Throughway Type	Cross Section Component		
Embankment (Ordinary section):	Protected shoulder: Outer shoulder : Carriageway : Inner shoulder : Median :	2 x 0.75 2 x 3.00 2 x 2x3.75 2 x1.00 2.00	Total width 26.50 m
Embankment (Interchange section)	Protected shoulder : Outer shoulder : Carriageway : Inner shoulder : Median :	2 x0.75 2 x6.50 2 x2x3.75 2 x 1.00 2.00	Total width 33.50 m
Red River bridge	Curbs : Non motercycle lanes Outer shoulders : Carriageways : Inner shoulders : Curbs : Side clearance :	2 x0.55 2 x3.5 2 x3.00 2 x2 x3.75 2x1.00 2 x0.55 0.9	Total width 33.10 m

Table 5.10 Cross Section Component for the Frontage Road Type

Frontage Road Type	Cross Section Component		
One way- Two lane (Type F-1, TypeF-2)	Protected shoulder : Side walk : Non motorcycle lane : Shoulder : Carriageway :	0.50 3.00 3.00 2 x0.50 2 x3.50	Total Width 14.50
Two way- Two lane (TypeF-3, TypeF-4)	Protected shoulder: Side walk : Shoulder : Carriageway :	0.50 2 x3.00 2 x0.50 2 x3.50	Total Width 14.50

Table 5.11 Application of the Throughway / Frontage Road Type

Sections	Section (STA)	Throughway Cross Section Type
Thanh Tri Side	0+000 - 1+112	with viaduct and both side frontage road (TypeF-1,2)
	1+112 - 5+ 630	with both side frontage (Type F-2)
	5+630 - 6+160	with one side frontage road (Type F-3,4)
Thanh Tri River	6+160 - 9+302	(Bridge)
Gia Lam Side	9+302 - 10+920	with one side frontage road (Type F3,4)
	10+920 - 12+831	without frontage roads

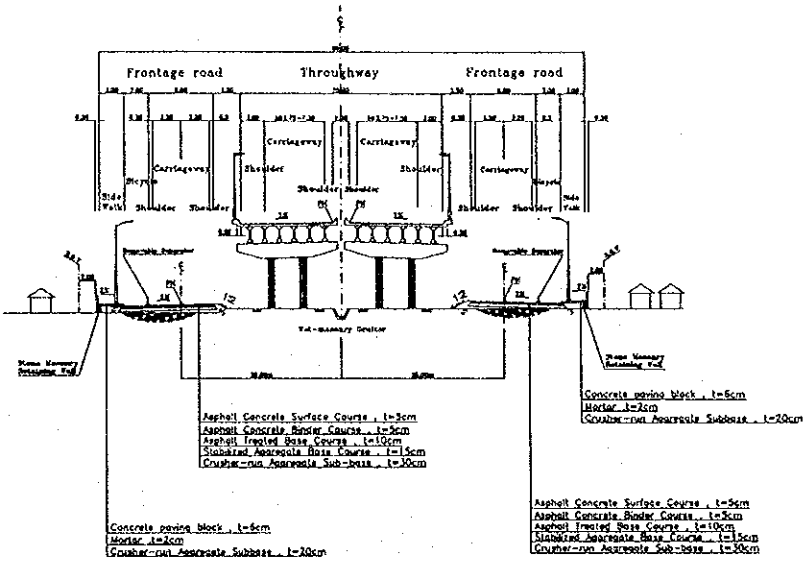
Note: The above sections include the bridge sections

Table 5.12 Application of the Ramp way Type

(unit: m)

Ramp-way Type	Cross section Component		Application
One way, one lane, with paking shoulder	Protected shoulder : Min. : Shoulder : Carriageway : Parking shoulder : Protected shoulder :	0.50 1.00 3.50 2.50 0.75	Nguyen Tam Trinh interchange, A,B ramps. Lin Nam interchange, A,B ramps.
One way, one lane, with paking shoulder and non-motorized	Protected shoulder : Min. : Non-motorcycle lane : Carriageway : Parking shoulder : Protected shoulder :	0.50 3.00 3.50 2.50 0.75	Lin Nam interchange, C,D ramps. Gia Lam interchange, A,B ramps.
One way, two lanes	Protected shoulder : Shoulder : Carriageway :	2 x0.75 2 x 1.00 2 x 3.50	Phap Van Cau Gie Interchange, A,B,C,D,EF,G,H ramps. NH5 interchange, A,B,C,D ramps.
Two way, Four lanes	Protected shoulder Outer shoulder Inner shoulder Carriageway	2 x 0.75 2 x 1.00 2 x 0.50 4 x 3.50	Phap Van Cau Gie Interchange, AB, EF ramps.

STA0+100
(PHAP VAN VIADUCT)



STA1+060
(PHAP VAN VIADUCT)

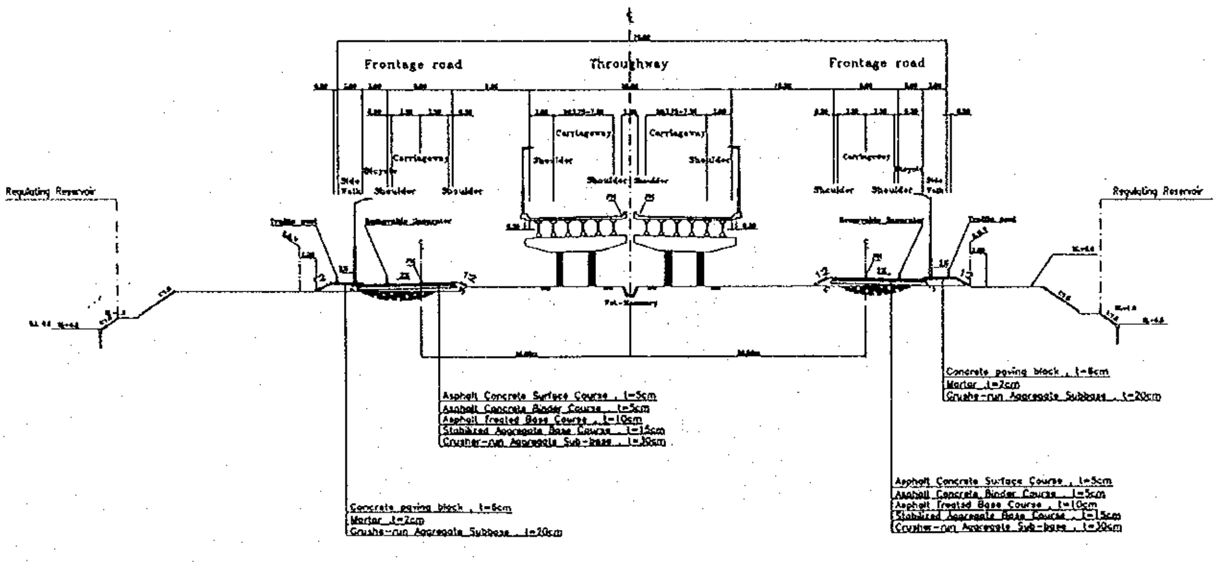
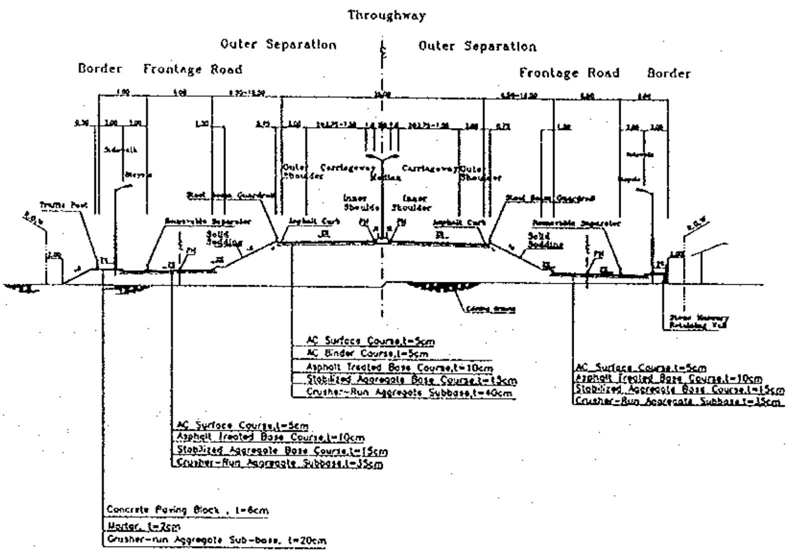


Figure 5.3 Typical Cross Section (1)

STA3+340
(THOUGHWAY WITH BOTH SIDE FRONTAGE ROAD)



STA7+620
(MAIN BRIDGE)

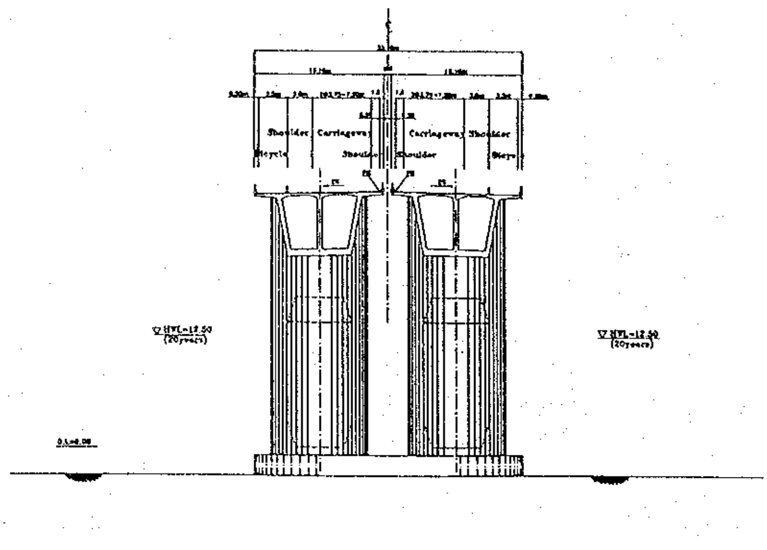
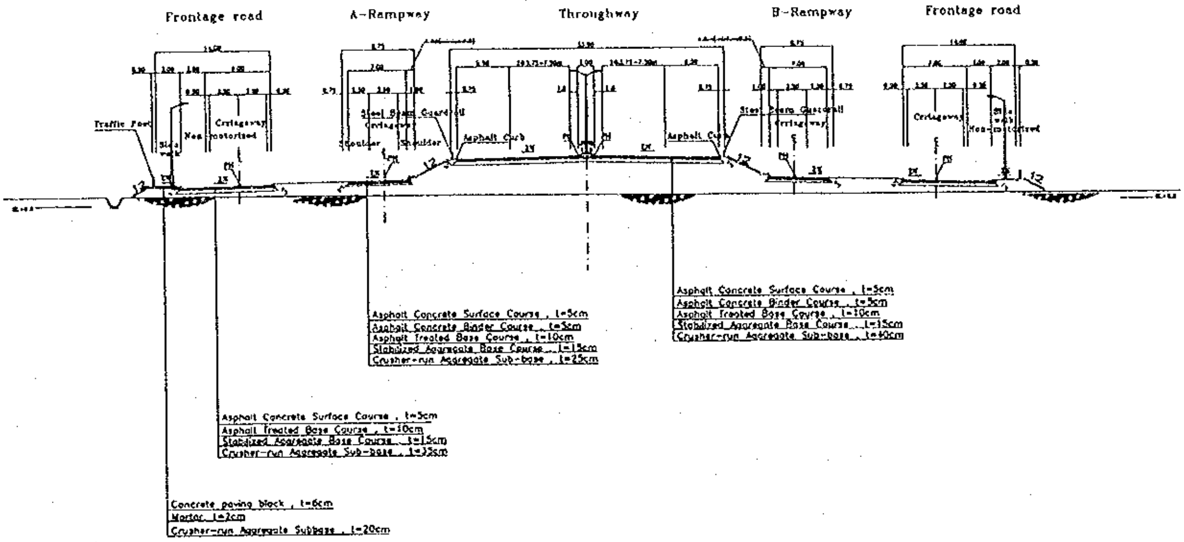


Figure 5.4 Typical Cross Section (2)

STA2+600
(NGUYEN TAM TRINH INTERCHANGE)



STA5+800
(LINH NAM INTERCHANGE)

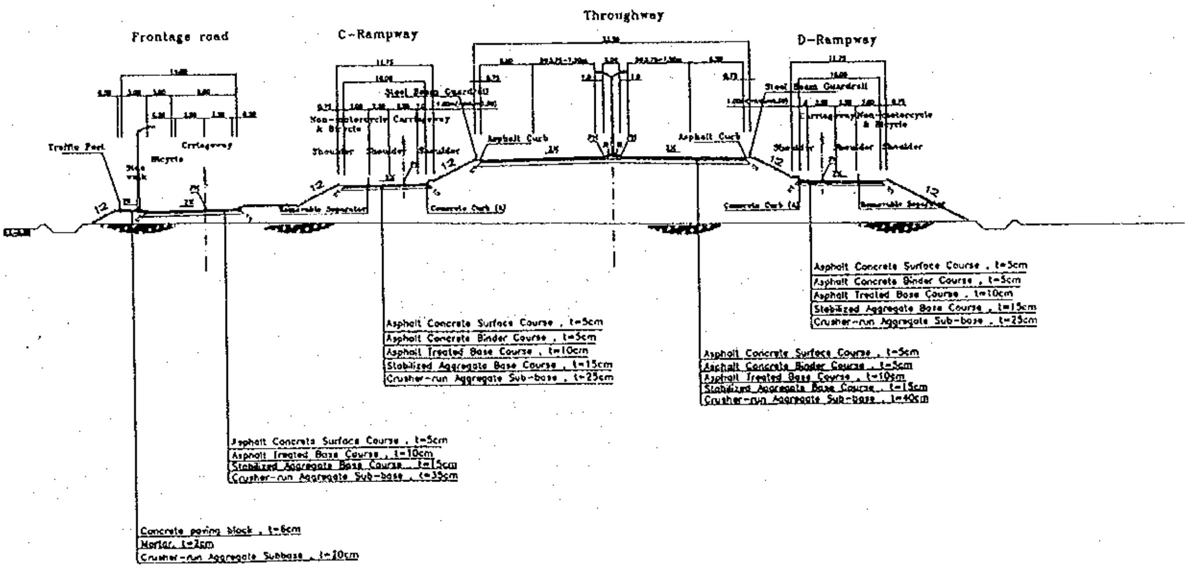
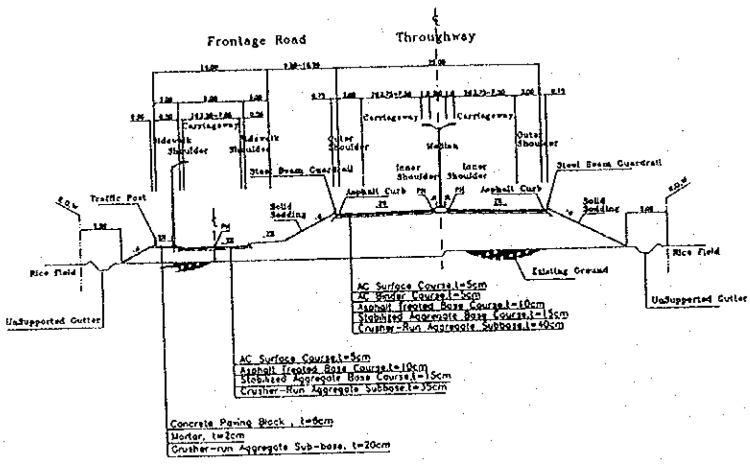


Figure 5.5 Typical Cross Section (3)

STA10+340
(THOUGHWAY WITH ONE SIDE FRONTAGE ROAD)



STA11+160
(THOUGHWAY WITHOUT FRONTAGE ROAD)

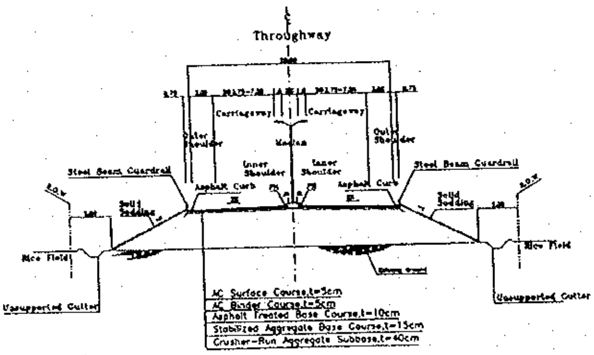


Figure 5.6 Typical Cross Section (4)

5.5 Pavement Design

Pavement design criteria was considered and decided based on the following standards:

- Vietnam Pavement Standard (Guide for design of flexible pavement structures 22-TCN 211-93)
- American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures, 1986
- Japanese Pavement Standard (Asphalt Pavement Outline published by Japan Road Association, 1992)

Performance and analysis period for pavement design are 15 years and the design conditions are as follows:

- Year 2003 assumes the beginning of operation year.
- Year 2018 is the end of the analysis and performance period.
- Year 2020 is reference year.

The forecasted daily traffic volume to estimate accumulative equivalent 18-kip single axle load (ESAL) were assumed from the results of the JICA feasibility study 1998.

(1) Required Structure Type and Thickness

Using the DNPS86/PCTM of Computer Soft program AADHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURE – 1986 issued by American Association of State, pavement type and thickness for the each road are summarized as shown in Table 5.13, Table 5.14, Table 5.15.

1) Toll Plaza (Cement Concrete Pavement)

Table 5.13 Pavement Structure for Toll Plaza

Material	Thickness (cm)
Cement Concrete	25
Sub-base Thickness	25

2) Throughway / Frontage road

Table 5.14 Pavement Structure for Throughway/Frontage Road

Material	Throughway	Pavement Thickness (cm) Frontage Road F-1	F-2
Asphalt Concrete Surface Course	5	5	5
Asphalt Concrete Binder Course	5	5	-
Asphalt Treated Base Course	10	10	10
Stabilized Aggregate Base Course	15	15	15
Crusher-run Aggregate Sub-base	40	30	35
Total	75	65	65

Note: F-1: Phap Van Cau Gie Section of frontage road
(Right side: STA 0+000-STA0+7590.256, Left side: STA 0+000-STA 0+770.646)
F-2: Other frontage road section

3) Ramp-way

Table 5.15 Pavement Structure for Ramp-way

Material	Pavement Thickness of Interchange Ramp		
	Phap Van Cau Gie	NH5	Other
Asphalt Concrete Surface Course	5	5	5
Asphalt Concrete Binder Course	5	5	-
Asphalt Treated Base Course	10	10	10
Stabilized Aggregate Base Course	15	15	15
Crusher-run Aggregate Sub-base	30	35	35
Total	65	70	65

Note: Others: Nguyen Tan Trinh Interchange, Ramp A,B, Linh Nam Interchange, Ramp A,B,C,D Gia Lam Dyke Interchange, A,B

5.6 Toll Barrier

Since an expressway is a toll road, it is necessary to install a facility to collect fees from the vehicles and toll barriers are provided for this purpose. The toll barrier is composed of toll office, toll gate (island, booth, gate, building) and plaza.

Location of the toll plaza was decided to be between Linh Nam interchange and Thanh Tri dyke road (the center of the Booth is at STA 6+060).
Based on following estimation and traffic demand in the year 2020, the required number of lanes (gates) was estimated at 4 lanes for all vehicles except motorcycles. For motorcycles, one lane is provided (Service time : 8 seconds, Service level : 2.0 vehicles). The toll gate lanes consist of the car and truck / bus lane: 3.20 m; heavy vehicle: 4.50m; bicycle lane: 3.0m and access lane for maintenance vehicle: 6.0m.

Cement concrete pavement was installed for 40 m to either both sides of the center of the gate to prevent pavement aging on the gate and its vicinity.

6. DETAILED DESIGN OF BRIDGES

6.1 General

As shown in Figure 6.1, there are eight bridge locations proposed in this project. The longest bridge in this project is the Red River Bridge (Thanh Tri Bridge) in Package 1. This bridge which crosses the Red River has a total length of 3,084 m and consists of seven parts.

There are three bridges in Package 2. The Gia Lam Road Bridge is proposed at an intersection point where the throughway is over the proposed new road. The Cau Bay Canal Bridge is located at the location where the alignment of throughway crosses the existing irrigation canal used for an adjacent agricultural area. The last bridge in Package 2 is the National Highway No. 5 Flyover, which is proposed for crossing over the existing National Highway No. 5 and railway. Furthermore, two ramp bridges are arranged in this area.

In Package 3, four bridges are proposed. The Phap Van Viaduct is a viaduct over the Phap Van Cau Gie Road and existing National Highway No. 1 and lands on the Linh Dam Lake area. Four connecting bridges of ramp way to the throughway are proposed. The second bridge is the Kim Nguu River Bridge, which is to be located over the existing Kim Nguu River. Bridges for the throughway and frontage road on both sides of the throughway are to be separately constructed in this section. The Nguyen Tam Trinh Bridge is proposed at the Nguyen Tam Trinh Interchange. The fourth bridge in Package 3 is proposed in order to ensure future traffic of the Linh Nam Road under the throughway and is named the Linh Nam Bridge.

Proposed locations and length of bridges in this project are summarized in Table 6.1 and Figure 6.1.

The width of bridge was selected in accordance with the highway design. The effective width (deck width) through the Red River Bridge is 15.0m, while that for other bridges in this project, excluding ramp bridges, is basically 11.5m. Frontage road bridge of Kim Nguu River Bridge has 14.0m effective width. The effective width of ramp bridges ranges from 9.0m to 10.5m based on alignment design of highway considering widening in the horizontally curved section.

Types of bridge width are listed in Table 6.2.

Table 6.1 List of Proposed Bridges in the Project

Construction Package	Name of Bridge			Length (m)	Proposed Location Beginning	Proposed Location End
Package 1	Red River Bridge (Thanh Tri Bridge)		S	3,084.0	STA 6+218.5	STA 9+302.5
			N	3,084.0	STA 6+218.5	STA 9+302.5
		Approach Bridge 2 (T) Thanh Tri side	S	246.0	STA 6+218.5	STA 6+464.5
			N	226.0	STA 6+218.5	STA 6+444.5
		Thanh Tri Dyke Bridge	S	290.0	STA 6+464.5	STA 6+754.5
			N	290.0	STA 6+444.5	STA 6+734.5
		Approach Bridge 1 (T) Thanh Tri side	S	530.0	STA 6+754.5	STA 7+284.5
			N	550.0	STA 6+734.5	STA 7+284.5
		Main Bridge	S	680.0	STA 7+284.5	STA 7+964.5
			N	680.0	STA 7+284.5	STA 7+964.5
		Approach Bridge 1 (G) Gia Lam side	S	850.0	STA 7+964.5	STA 8+814.5
			N	850.0	STA 7+964.5	STA 8+814.5
		Gia Lam Dyke Bridge	S	290.0	STA 8+814.5	STA 9+104.5
			N	290.0	STA 8+814.5	STA 9+104.5
		Approach Bridge 2 (G) Gia Lam side	S	198.0	STA 9+104.5	STA 9+302.5
			N	198.0	STA 9+104.5	STA 9+302.5
Package 2	Gia Lam Road Bridge		S	33.0	STA 10+903.5	STA 10+936.5
			N	33.0	STA 10+903.5	STA 10+936.5
	Cau Bay Canal Bridge		S	249.0	STA 11+382.0	STA 11+631.0
			N	233.0	STA 11+382.0	STA 11+615.0
	National Highway No.5 Flyover		S	695.0	STA 11+768.5	STA 12+463.5
			N	695.0	STA 11+768.5	STA 12+463.5
Package 3	Phap Van Cau Gie Viaduct		S	575.0	STA 0+536.5	STA 1+111.5
			N	575.0	STA 0+536.5	STA 1+111.5
	Kim Guu River Bridge		S	99.0	STA 1+647.0	STA 1+746.0
			N	99.0	STA 1+647.0	STA 1+746.0
	Nguyen Tam Trin Bridge		S	50.0	STA 2+775.0	STA 2+825.0
			N	50.0	STA 2+775.0	STA 2+825.0
	Linh Nam Bridge		S	50.0	STA 5+605.0	STA 5+655.0
			N	50.0	STA 5+605.0	STA 5+655.0

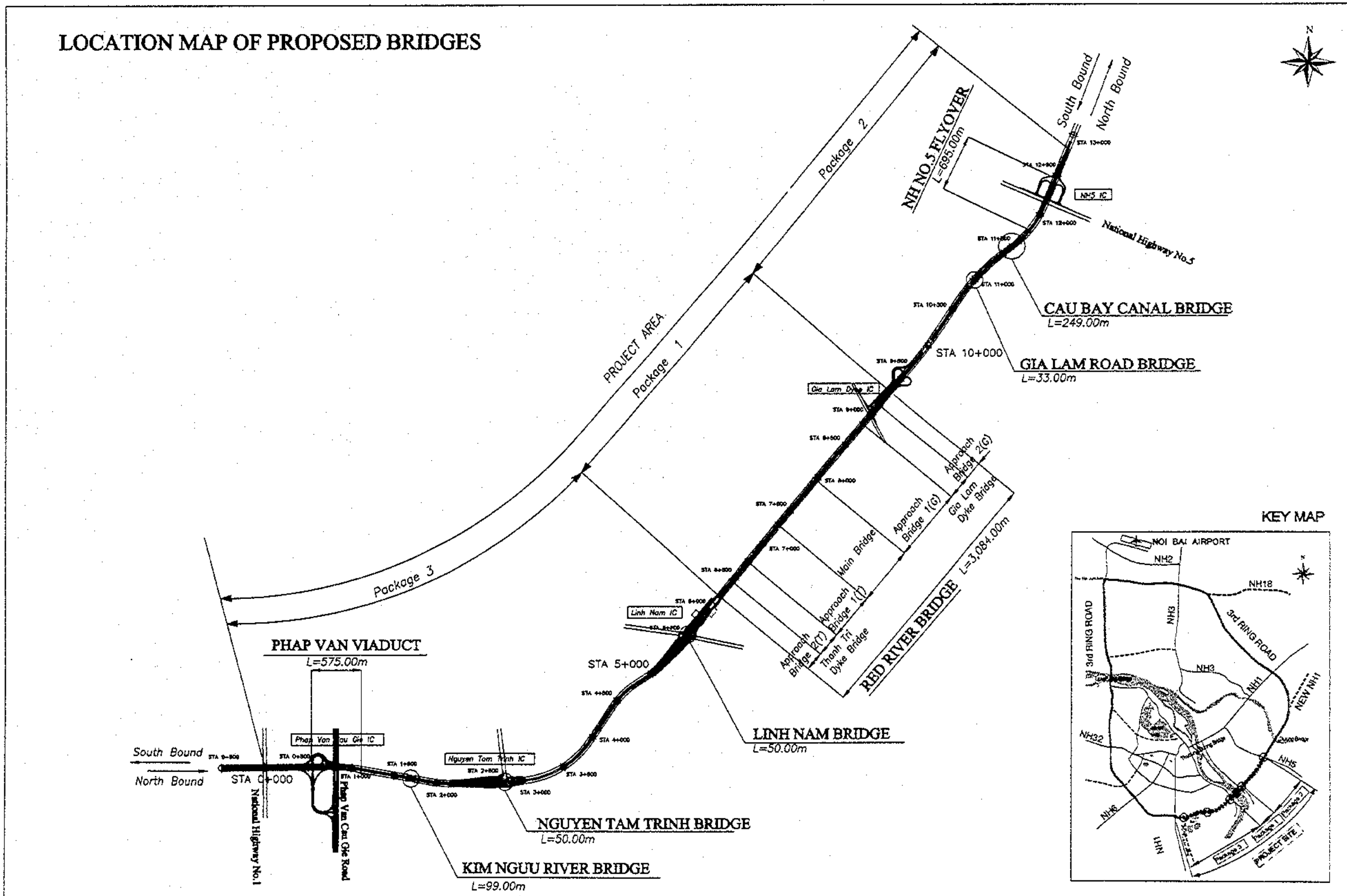
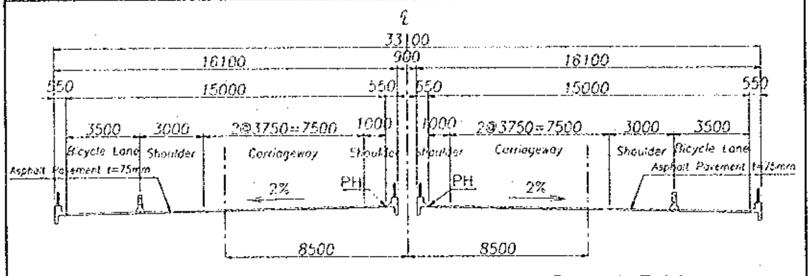
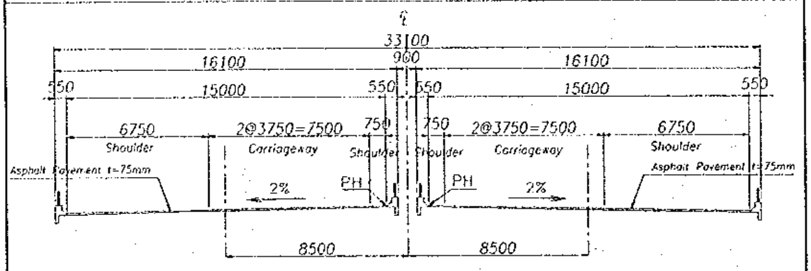
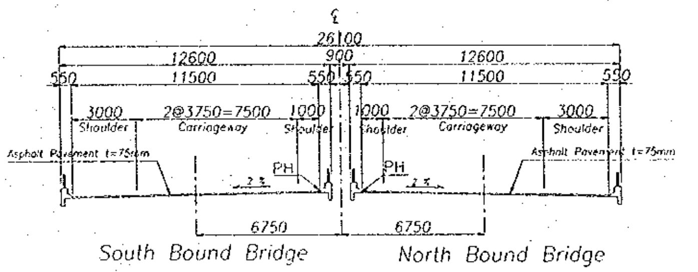
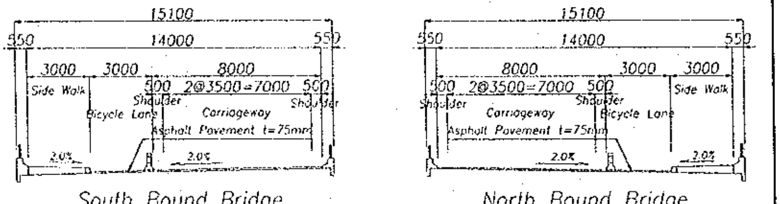
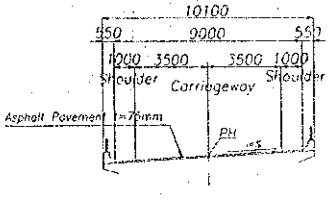


Figure 6.1 Location Map of Proposed Bridges

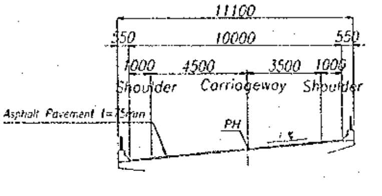
Table 6.2 List of Types of Bridge Width in the Project

Types of Bridge Width	Bridges to be applied to
 South Bound Bridge North Bound Bridge	<u>For throughway bridges</u> Red River Bridge - Main Bridge - Approach Bridge 1 - Dyke Bridge - Approach Bridge 2
 South Bound Bridge North Bound Bridge	<u>For throughway bridges</u> National Highway No.5 Flyover (section near A2 abutment)
 South Bound Bridge North Bound Bridge	<u>For throughway bridges</u> Phap Van Viaduct Kim Nguu River Bridge (throughway) Nguyen Tam Trinh Bridge Linh Nam Bridge Gia Lam Road Bridge Cau Bay Canal Bridge National Highway No.5 Flyover (section near A1 abutment)
 South Bound Bridge North Bound Bridge	<u>For frontage road bridges</u> Kim Nguu River Bridge (frontage road)

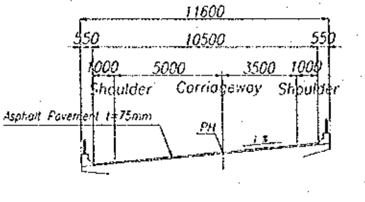
<u>For Interchange bridges</u>



Phap Van I.C – B & C-Ramp



Phap Van I.C – A-Ramp
NH No.5 I.C – A-Ramp



NH No.5 I.C – B-Ramp

Length and span arrangement of bridges have been proposed so as to satisfy the following conditions:

- The location of abutment should be determined so that the height of abutment will be less than the critical embankment height.

- Control points for the bridge span arrangement should be precisely understood so that proposed bridges would not obstruct the existing and / or proposed objects such as roads and canals.

- Span arrangement should be determined by selecting appropriate span length and applicable bridge type considering economical construction.

Proposed span arrangement and types of bridge superstructure are listed in Table 6.3.

The total length of bridges in Packages 1 through 3 is 10,460m and the total area of bridge is 154,360m^2. Table 6.4 shows the estimated area of proposed bridges in this project.

Table 6.3 List of Span Arrangement and Superstructure Types in the Project

PACKAGE	BRIDGE NAME	BOUND	BRIDGE LENGTH (m)	EFFECTIVE WIDTH (m)	SPAN ARRANGEMENT (m)	TYPE OF SUPERSTRUCTURE
Package 1 (Red River Bridge) from STA 6+218.5 to STA 9+302.5	Approach Bridge 2 (T)	S	246.0	15.000	33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 28.0 / 20.0	8 @ Simple PC I-girder
		N	226.0	15.000	33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 28.0	7 @ Simple PC I-girder
	Thanh Tri Dyke Bridge	S	290.0	15.000	80.0 / 130.0 / 80.0	3 Span Continuous PC Box-girder
		N	290.0	15.000		
	Approach Bridge 1 (T)	S	530.0	15.000	30.0 / 50.0 / 50.0 / 50.0 / 50.0 ; 50.0 / 50.0 / 50.0 / 50.0 / 50.0 / 50.0	5 Span Continuous PC Box-girder ; 6 Span Continuous PC Box-girder
		N	550.0	15.000	50.0 / 50.0 / 50.0 / 50.0 / 50.0 ; 50.0 / 50.0 / 50.0 / 50.0 / 50.0 / 50.0	5 Span Continuous PC Box-girder ; 6 Span Continuous PC Box-girder
	Main Bridge	S	680.0	15.000	80.0 / 130.0 / 130.0 / 130.0 / 130.0 / 80.0	6 Span Continuous PC Box-girder
		N	680.0	15.000		
	Approach Bridge 1 (G)	S	850.0	15.000	50.0 / 50.0 / 50.0 / 50.0 / 50.0 / 50.0 ; 50.0 / 50.0 / 50.0 / 50.0 / 50.0 ; 50.0 / 50.0 / 50.0 / 50.0 / 50.0 / 50.0	6 Span Continuous PC Box-girder ; 5 Span Continuous PC Box-girder ; 6 Span Continuous PC Box-girder
		N	850.0	15.000		
	Gia Lam Dyke Bridge	S	290.0	15.000	80.0 / 130.0 / 80.0	3 Span Continuous PC Box-girder
		N	290.0	15.000		
	Approach Bridge 2 (G)	S	198.0	15.000	33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0	6 @ Simple PC I-girder
		N	198.0	15.000		
Package 2 (Gia Lam) from STA 9+302.5 to STA 12+831.9	Gia Lam Road Bridge	S	33.0	11.500	33.0	Simple PC-I
		N	33.0	11.500		
	Cau Bay Canal Bridge	S	249.0	11.500	33.0 ; 50.0 ; 33.0 / 33.0 ; 50.0 / 50.0	Simple PC-I ; Simple PC Box ; 2 @ Simple PC I-girder ; 2 Span Continuous PC Box-girder
		N	233.0	11.500	50.0 / 50.0 ; 33.0 ; 50.0 / 50.0	2 Span Continuous PC Box-girder ; Simple PC-I ; 2 Span Continuous PC Box-girder
	NH No.5 Flyover	S	695.0	11.50-30.26	33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 ; 35.0 ; 33.0 / 33.0 ; 28.0 / 28.0 / 28.0 / 28.0 ; 20.0 ; 33.0 / 33.0 / 33.0	11 @ Simple PC I-girder ; Simple PC-I ; 2 @ Simple PC I-girder ; 2 @ Simple PC I-girder ; Simple PC-I ; 3 @ Simple PC I-girder
		N	695.0	11.50-26.91		
	NH No.5 Interchange Ramp Bridges	A-Ramp	85.0	9.990 - 10.500	17.0 / 17.0 / 17.0	3 Span Continuous RC Hollow Slab
		B-Ramp	85.0	9.990 - 10.500	17.0 / 17.0 / 17.0 / 17.0	4 Span Continuous RC Hollow Slab
Package 3 (Thanh Tri) from STA 0+000 to STA 6+218.5	Phap Van Viaduct	S	575.0	11.50-30.43	33.0 / 33.0 ; 28.0 / 28.0 / 28.0 / 28.0 / 28.0 ; 35.0 / 35.0 ; 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 / 33.0 ; 25.0	2@Simple PC I-girder ; 5 @ Simple PC I-girder ; 2@Simple PC I-girder ; 8 @ Simple PC I-girder ; Simple PC-I
		N	575.0	11.50-26.87		
	Kim Nguu River Bridge (Throughway)	S	99.0	11.500	33.0 / 33.0 / 33.0	3 @ Simple PC I-girder
		N	99.0	11.500		
	Kim Nguu River Bridge (Frontage Road)	S	99.0	14.000	33.0 / 33.0 / 33.0	3 @ Simple PC I-girder
		N	99.0	14.000		
	Nguyen Tam Trinh Bridge	S	50.0	11.500	50.0	Simple PC Box
		N	50.0	11.500		
	Linh Nam Bridge	S	50.0	11.500	50.0	Simple PC Box
		N	50.0	11.500		
	Phap Van Cau Gie Interchange Bridges	A-Ramp	85.0	9.00 - 10.00	17.0 / 17.0 / 17.0 ; 17.0 / 17.0 / 17.0	3 Span Continuous RC Hollow Slab ; 3 Span Continuous RC Hollow Slab
		B-Ramp	85.0	9.00 - 10.00	17.0 / 17.0 / 17.0 ; 17.0 / 17.0 / 17.0 / 17.0	3 Span Continuous RC Hollow Slab ; 4 Span Continuous RC Hollow Slab
		C-Ramp	85.0	9.00 - 10.00	17.0 / 17.0 / 17.0 / 17.0 ; 17.0 / 17.0 / 17.0 / 17.0	4 Span Continuous RC Hollow Slab ; 4 Span Continuous RC Hollow Slab

Table 6.4 List of the Area of Proposed Bridges in the Project

PACKAGE	LOCATION	BRIDGE NAME	BOUND	STATION		EFFECTIVE WIDTH	BRIDGE LENGTH & AREA									
							CANTILEVER		PC BOX		PC I-GIRDER		RC HOLLOW		TOTAL	
							Length	Area	Length	Area	Length	Area	Length	Area	Length	Area
				Beginning	End	(m)	(m)	(m^2)	(m)	(m^2)	(m)	(m^2)	(m)	(m^2)	(m)	(m^2)
Package 1 from STA 6+218.5 to STA 9+302.5	Throughway	Approach Bridge 2 (T)	N	6+218.5	6+444.5	15.000	-	-	-	-	226.00	3,390	-	-	226.00	3,390
			S	6+218.5	6+464.5	15.000	-	-	-	-	246.00	3,690	-	-	246.00	3,690
		Thanh Tri Dyke Bridge	N	6+444.5	6+734.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	6+464.5	6+754.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 1 (T)	N	6+734.5	7+284.5	15.000	-	-	550.00	8,250	-	-	-	-	550.00	8,250
			S	6+754.5	7+284.5	15.000	-	-	530.00	7,950	-	-	-	-	530.00	7,950
		Main Bridge	N	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
			S	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
		Approach Bridge 1 (G)	N	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
			S	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
		Gia Lam Dyke Bridge	N	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 2 (G)	N	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
			S	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
	RED RIVER BRIDGE TOTAL (TOTAL OF PACKAGE 1)		N	-	-	-	1,260.00	18,900	1,400.00	21,000	424.00	6,360	0.00	0	3,084.00	46,260
			S	-	-	-	1,260.00	18,900	1,380.00	20,700	444.00	6,660	0.00	0	3,084.00	46,260
			all	-	-	-	**2,520.00**	**37,800**	**2,780.00**	**41,700**	**868.00**	**13,020**	**0.00**	**0**	**6,168.00**	**92,520**
Package 2 from STA 9+302.5 to STA 12+831.9	Throughway	Gia Lam Road Bridge	N	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
			S	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
		Cau Bay Canal Bridge	N	11+382	11+615	11.500	-	-	200.00	2,300	33.00	380	-	-	233.00	2,680
			S	11+382	11+631	11.500	-	-	150.00	1,725	99.00	1,139	-	-	249.00	2,864
		NH No.5 Flyover	N	11+768.5	12+463.5	11.50 - 26.91	-	-	-	-	695.00	10,027	-	-	695.00	10,027
			S	11+768.5	12+463.5	11.50 - 30.26	-	-	-	-	695.00	10,985	-	-	695.00	10,985
		SUBTOTAL	N	-	-	-	0.00	0	200.00	2,300	761.00	10,786	0.00	0	961.00	13,086
			S	-	-	-	0.00	0	150.00	1,725	827.00	12,503	0.00	0	977.00	14,228
			N + S	-	-	-	**0.00**	**0**	**350.00**	**4,025**	**1,588.00**	**23,289**	**0.00**	**0**	**1,938.00**	**27,314**
	Others	Ramp Bridge	-	-	-	9.990 - 10.268	-	-	-	-	-	-	119.00	1,197	119.00	1,197
		SUBTOTAL	-	-	-	-	**0.00**	**0**	**0.00**	**0**	**0.00**	**0**	**119.00**	**1,197**	**119.00**	**1,197**
	TOTAL (PACKAGE 2)		**all**	-	-	-	**0.00**	**0**	**350.00**	**4,025**	**1,588.00**	**23,289**	**119.00**	**1,197**	**2,057.00**	**28,511**
Package 3 from STA 0+000 to STA 6+218.5	Throughway	Phap Van Viaduct	N	0+536.5	1+111.5	11.50 - 26.87	-	-	-	-	575.00	10,421	-	-	575.00	10,421
			S	0+536.5	1+111.5	11.50 - 30.43	-	-	-	-	575.00	9,975	-	-	575.00	9,975
		Kim Nguu River Bridge	N	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
			S	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
		Nguyen Tam Trinh Bridge	N	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		Linh Nam Bridge	N	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		SUBTOTAL	N	-	-	-	0.00	0	100.00	1,150	674.00	11,560	0.00	0	774.00	12,710
			S	-	-	-	0.00	0	100.00	1,150	674.00	11,114	0.00	0	774.00	12,264
			N + S	-	-	-	**0.00**	**0**	**200.00**	**2,300**	**1,348.00**	**22,674**	**0.00**	**0**	**1,548.00**	**24,974**
	Others	Kim Nguu River Bridge (F)	N	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
			S	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
		Ramp Bridge	-	-	-	9.00 - 10.00	-	-	-	-	-	-	357.00	3,315	357.00	3,315
		Phap Van - Cau Gie Flyover	-	-	-	18.000	-	-	-	-	132.00	2,376	-	-	132.00	2,376
		SUBTOTAL	**all**	-	-	-	**0.00**	**0**	**0.00**	**0**	**330.00**	**5,040**	**357.00**	**3,315**	**687.00**	**8,355**
	TOTAL (PACKAGE 3)		**all**	-	-	-	**0.00**	**0**	**200.00**	**2,300**	**1,678.00**	**27,714**	**357.00**	**3,315**	**2,235.00**	**33,329**
GRAND TOTAL (PACAKGES 1 through 3)			all of all	-	-	-	2,520.00	37,800	3,330.00	48,025	4,134.00	64,023	476.00	4,512	10,460.00	154,360

Table 6.3 List of Span Arrangement and Superstructure Types in the Project

PACKAGE	BRIDGE NAME	BOUND	BRIDGE LENGTH (m)	EFFECTIVE WIDTH (m)	SPAN ARRANGEMENT (m) / TYPE OF SUPERSTRUCTURE
Package 1 (Red River Bridge) from STA 6+218.5 to STA 9+302.5	Approach Bridge 2 (T)	S	246.0	15.000	33.0 33.0 33.0 33.0 33.0 33.0 28.0 20.0 — 8 @ Simple PC I-girder
		N	226.0	15.000	33.0 33.0 33.0 33.0 33.0 33.0 28.0 — 7 @ Simple PC I-girder
	Thanh Tri Dyke Bridge	S	290.0	15.000	80.0 130.0 80.0 — 3 Span Continuous PC Box-girder
		N	290.0	15.000	
	Approach Bridge 1 (T)	S	530.0	15.000	30.0 50.0 50.0 50.0 50.0 — 5 Span Continuous PC Box-girder | 50.0 50.0 50.0 50.0 50.0 50.0 — 6 Span Continuous PC Box-girder
		N	550.0	15.000	50.0 50.0 50.0 50.0 50.0 — 5 Span Continuous PC Box-girder | 50.0 50.0 50.0 50.0 50.0 50.0 — 6 Span Continuous PC Box-girder
	Main Bridge	S	680.0	15.000	80.0 130.0 130.0 130.0 130.0 80.0 — 6 Span Continuous PC Box-girder
		N	680.0	15.000	
	Approach Bridge 1 (G)	S	850.0	15.000	50.0 50.0 50.0 50.0 50.0 50.0 — 6 Span Continuous PC Box-girder | 50.0 50.0 50.0 50.0 50.0 — 5 Span Continuous PC Box-girder | 50.0 50.0 50.0 50.0 50.0 50.0 — 6 Span Continuous PC Box-girder
		N	850.0	15.000	
	Gia Lam Dyke Bridge	S	290.0	15.000	80.0 130.0 80.0 — 3 Span Continuous PC Box-girder
		N	290.0	15.000	
	Approach Bridge 2 (G)	S	198.0	15.000	33.0 33.0 33.0 33.0 33.0 33.0 — 6 @ Simple PC I-girder
		N	198.0	15.000	
Package 2 (Gia Lam) from STA 9+302.5 to STA 12+831.9	Gia Lam Road Bridge	S	33.0	11.500	33.0 — Simple PC-I
		N	33.0	11.500	
	Cau Bay Canal Bridge	S	249.0	11.500	33.0 — Simple PC-I | 50.0 — Simple PC Box | 33.0 33.0 — 2 @ Simple PC I-girder | 50.0 50.0 — 2 Span Continuous PC Box-girder
		N	233.0	11.500	50.0 50.0 — 2 Span Continuous PC Box-girder | 33.0 — Simple PC-I | 50.0 50.0 — 2 Span Continuous PC Box-girder
	NH No.5 Flyover	S	695.0	11.50-30.26	33.0 33.0 33.0 33.0 33.0 33.0 33.0 33.0 33.0 33.0 33.0 — 11 @ Simple PC I-girder | 35.0 — Simple PC-I | 33.0 33.0 — 2 @ Simple PC I-girder | 28.0 28.0 28.0 28.0 — 2 @ Simple PC I-girder | 20.0 — Simple PC-I | 33.0 33.0 33.0 — 3 @ Simple PC I-girder
		N	695.0	11.50-26.91	
	NH No.5 Interchange Ramp Bridges	A-Ramp	85.0	9.990 - 10.500	17.0 17.0 17.0 — 3 Span Continuous RC Hollow Slab
		B-Ramp	85.0	9.990 - 10.500	17.0 17.0 17.0 17.0 — 4 Span Continuous RC Hollow Slab
Package 3 (Thanh Tri) from STA 0+000 to STA 6+218.5	Phap Van Viaduct	S	575.0	11.50-30.43	33.0 33.0 — 2@Simple PC I-girder | 28.0 28.0 28.0 28.0 28.0 — 5 @ Simple PC I-girder | 35.0 35.0 — 2@Simple PC I-girder | 33.0 33.0 33.0 33.0 33.0 33.0 33.0 33.0 — 8 @ Simple PC I-girder | 25.0 — Simple PC-I
		N	575.0	11.50-26.87	
	Kim Nguu River Bridge (Throughway)	S	99.0	11.500	33.0 33.0 33.0 — 3 @ Simple PC I-girder
		N	99.0	11.500	
	Kim Nguu River Bridge (Frontage Road)	S	99.0	14.000	33.0 33.0 33.0 — 3 @ Simple PC I-girder
		N	99.0	14.000	
	Nguyen Tam Trinh Bridge	S	50.0	11.500	50.0 — Simple PC Box
		N	50.0	11.500	
	Linh Nam Bridge	S	50.0	11.500	50.0 — Simple PC Box
		N	50.0	11.500	
	Phap Van Cau Gie Interchange Bridges	A-Ramp	85.0	9.00 - 10.00	17.0 17.0 17.0 — 3 Span Continuous RC Hollow Slab | 17.0 17.0 17.0 — 3 Span Continuous RC Hollow Slab
		B-Ramp	85.0	9.00 - 10.00	17.0 17.0 17.0 — 3 Span Continuous RC Hollow Slab | 17.0 17.0 17.0 17.0 — 4 Span Continuous RC Hollow Slab
		C-Ramp	85.0	9.00 - 10.00	17.0 17.0 17.0 17.0 — 4 Span Continuous RC Hollow Slab | 17.0 17.0 17.0 17.0 — 4 Span Continuous RC Hollow Slab

Table 6.4 List of the Area of Proposed Bridges in the Project

PACKAGE	LOCATION	BRIDGE NAME	BOUND	STATION Beginning	STATION End	EFFECTIVE WIDTH (m)	CANTILEVER Length (m)	CANTILEVER Area (m²)	PC BOX Length (m)	PC BOX Area (m²)	PC I-GIRDER Length (m)	PC I-GIRDER Area (m²)	RC HOLLOW Length (m)	RC HOLLOW Area (m²)	TOTAL Length (m)	TOTAL Area (m²)
Package 1 from STA 6+218.5 to STA 9+302.5	Throughway	Approach Bridge 2 (T)	N	6+218.5	6+444.5	15.000	-	-	-	-	226.00	3,390	-	-	226.00	3,390
			S	6+218.5	6+464.5	15.000	-	-	-	-	246.00	3,690	-	-	246.00	3,690
		Thanh Tri Dyke Bridge	N	6+444.5	6+734.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	6+464.5	6+754.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 1 (T)	N	6+734.5	7+284.5	15.000	-	-	550.00	8,250	-	-	-	-	550.00	8,250
			S	6+754.5	7+284.5	15.000	-	-	530.00	7,950	-	-	-	-	530.00	7,950
		Main Bridge	N	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
			S	7+284.5	7+964.5	15.000	680.00	10,200	-	-	-	-	-	-	680.00	10,200
		Approach Bridge 1 (G)	N	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
			S	7+964.5	8+814.5	15.000	-	-	850.00	12,750	-	-	-	-	850.00	12,750
		Gia Lam Dyke Bridge	N	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
			S	8+814.5	9+104.5	15.000	290.00	4,350	-	-	-	-	-	-	290.00	4,350
		Approach Bridge 2 (G)	N	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
			S	9+104.5	9+302.5	15.000	-	-	-	-	198.00	2,970	-	-	198.00	2,970
	RED RIVER BRIDGE TOTAL (TOTAL OF PACKAGE 1)		N	-	-	-	1,260.00	18,900	1,400.00	21,000	424.00	6,360	0.00	0	3,064.00	46,260
			S	-	-	-	1,260.00	18,900	1,380.00	20,700	444.00	6,660	0.00	0	3,084.00	46,260
			all	-	-	-	**2,520.00**	**37,800**	**2,780.00**	**41,700**	**868.00**	**13,020**	**0.00**	**0**	**6,168.00**	**92,520**
Package 2 from STA 9+302.5 to STA 12+831.9	Throughway	Gia Lam Road Bridge	N	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
			S	10+903.5	10+936.5	11.500	-	-	-	-	33.00	380	-	-	33.00	380
		Cau Bay Canal Bridge	N	11+382	11+615	11.500	-	-	200.00	2,300	33.00	380	-	-	233.00	2,680
			S	11+382	11+631	11.500	-	-	150.00	1,725	99.00	1,139	-	-	249.00	2,864
		NH No.5 Flyover	N	11+768.5	12+463.5	11.50 - 26.91	-	-	-	-	695.00	10,027	-	-	695.00	10,027
			S	11+768.5	12+463.5	11.50 - 30.26	-	-	-	-	695.00	10,985	-	-	695.00	10,985
		SUBTOTAL	N	-	-	-	0.00	0	200.00	2,300	761.00	10,786	0.00	0	961.00	13,086
			S	-	-	-	0.00	0	150.00	1,725	827.00	12,503	0.00	0	977.00	14,228
			N + S	-	-	-	0.00	0	350.00	4,025	1,588.00	23,289	0.00	0	1,938.00	27,314
	Others	Ramp Bridge	-	-	-	9.990 - 10.268	-	-	-	-	-	-	119.00	1,197	119.00	1,197
		SUBTOTAL	-	-	-	-	0.00	0	0.00	0	0.00	0	119.00	1,197	119.00	1,197
	TOTAL (PACKAGE 2)		all	-	-	-	0.00	0	350.00	4,025	1,588.00	23,289	119.00	1,197	2,057.00	28,511
Package 3 from STA 0+000 to STA 6+218.5	Throughway	Phap Van Viaduct	N	0+536.5	1+111.5	11.50 - 26.87	-	-	-	-	575.00	10,421	-	-	575.00	10,421
			S	0+536.5	1+111.5	11.50 - 30.43	-	-	-	-	575.00	9,975	-	-	575.00	9,975
		Kim Nguu River Bridge	N	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
			S	1+647	1+746	11.500	-	-	-	-	99.00	1,139	-	-	99.00	1,139
		Nguyen Tam Trinh Bridge	N	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	2+775	2+825	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		Linh Nam Bridge	N	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
			S	5+605	5+655	11.500	-	-	50.00	575	-	-	-	-	50.00	575
		SUBTOTAL	N	-	-	-	0.00	0	100.00	1,150	674.00	11,560	0.00	0	774.00	12,710
			S	-	-	-	0.00	0	100.00	1,150	674.00	11,114	0.00	0	774.00	12,264
			N + S	-	-	-	0.00	0	200.00	2,300	1,348.00	22,674	0.00	0	1,548.00	24,974
	Others	Kim Nguu River Bridge (F)	N	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
			S	-	-	14.000	-	-	-	-	99.00	1,332	-	-	99.00	1,332
		Ramp Bridge	-	-	-	9.00 - 10.00	-	-	-	-	-	-	357.00	3,315	357.00	3,315
		Phap Van - Cau Gie Flyover	-	-	-	18.000	-	-	-	-	132.00	2,376	-	-	132.00	2,376
		SUBTOTAL	all	-	-	-	0.00	0	0.00	0	330.00	5,040	357.00	3,315	687.00	8,355
	TOTAL (PACKAGE 3)		all	-	-	-	0.00	0	200.00	2,300	1,678.00	27,714	357.00	3,315	2,235.00	33,329
GRAND TOTAL (PACAKGES 1 through 3)			all of all	-	-	-	2,520.00	37,800	3,330.00	48,025	4,134.00	64,023	476.00	4,512	10,460.00	154,360

6.2 Substructure

(1) Piers

In this project, several types of pier have been used so as to satisfy the required conditions such as type of superstructure, crossing road and canal, aesthetic shape and structural stability.

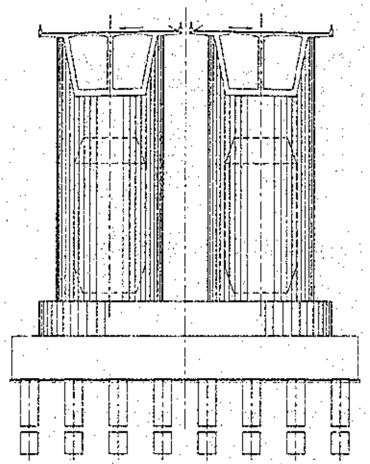
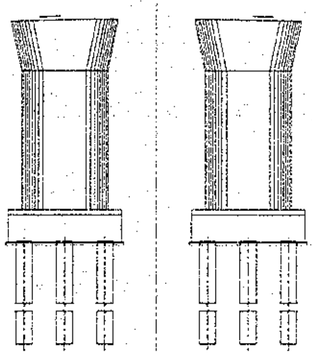
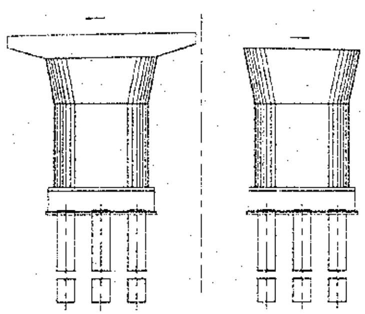
Substructure types used in this project are listed in Table 6.5.

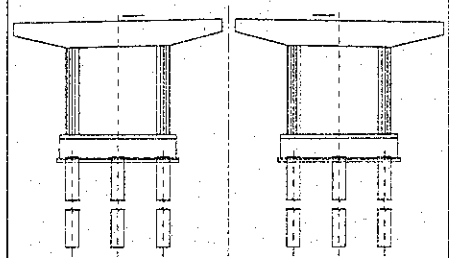
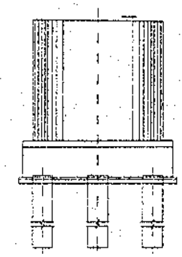
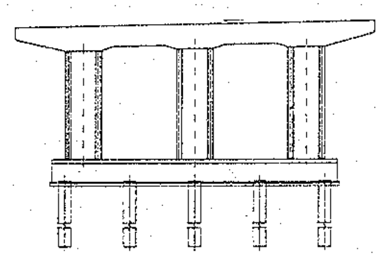
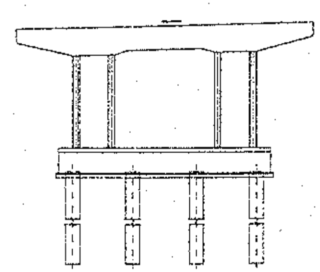
Selection of substructure type was carried out considering the following basic concepts:

- Piers to be located in the river stream and river land should be the wall piers with oval cross section so as not to disturb water flow.
- Shapes of piers of viaduct and flyover should be designed from an aesthetic viewpoint considering conditions such as land use, adjacent living environment and tradition of local area.
- Construction cost of piers should be minimized for the economical construction.

A total number of 261 substructures has been proposed in this project. A breakdown shows 235 piers and 26 abutments as listed in Table 6.6 and this Table also shows applied types and proposed height of substructures.

Table 6.5 List of Substructure Types in the Project

Type of Substructure	Application
	**Integrated Solid Wall Pier** This type without bridge bearing was applied to piers of Main Bridge and Dyke Bridges.
	**Solid Wall Pier** This type with tapered pier top was used for piers of Approach Bridge 1.
	**Solid Wall Hammerhead Pier** This type was applied to boundary piers between Approach Bridge 2 and Dyke Bridge.

Type of Substructure	Application
	**Hammerhead Pier** This type was applied to piers which support PC I-girders.
	**Solid wall Pier** This type was applied to piers support PC box-girder of the Cau Bay Canal Bridge
	**Three-column Hammerhead Pier** This type was used for Phap Van Viaduct and NH5 flyover.
	**Two-Column Hammerhead Pier** This type was used for Phap Van Viaduct and NH5 flyover.

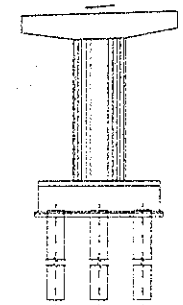
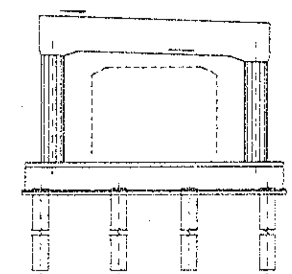
Type of Substructure	Application
	**Hammerhead Pier** This type was used for piers of Ramp Bridges (RC hollow slab).
	**Two-column Bent Pier** This type was only used for Pc7 pier of C-ramp bridge of Phap Van I.C.
	**ABUTMENT** Cantilever wall abutment This type of abutment was applied to all abutments in this project.

Table 6.6 List of Substructures in the Project

PACKAGE 1 (Red River Bridge) STA 6+218.5 to STA 9+302.5

RED RIVER BRIDGE

		Approach Bridge 2(T)								Thanh Tri Dyke Bridge				Approach Bridge 1(T)											Main Bridge				
South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7aL	P7bL	P8L	P9L	P10L	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	P22L	P23L	P24L	P25L	P26L
	Type	⊥	T	T	T	T	T	T	T	T	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
	Height	10.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	15.5	14.0	16.0	21.0	20.0	20.0	20.0	21.0	21.0	19.0	18.0	19.0	19.0	34.0	34.0	32.5	33.0	33.0	33.0	32.5
North Bound	Name		P1R	P2R	P3R	P4R	P5R	P6R		P7R	P8R	P9R	P10R	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R	P22R	P23R	P24R	P25R	P26R
	Type		T	T	T	T	T	T		T	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
	Height		9.0	10.0	11.0	12.0	13.0	14.0		15.0	14.0	16.0	21.0	20.0	20.0	20.0	21.0	21.0	19.0	18.0	19.0	19.0	34.0	34.0	32.5	33.0	33.0	33.0	32.5

		Approach Bridge 1(G)																	Gia Lam Dyke Bridge				Approach Bridge 2(G)					
South Bound	Name	P27L	P28L	P29L	P30L	P31L	P32L	P33L	P34L	P35L	P36L	P37L	P38L	P39L	P40L	P41L	P42L	P43L	P44L	P45L	P46L	P47L	P48L	P49L	P50L	P51L	P52L	A2
	Type	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	T	T	T	T	T	T	⊥
	Height	35.0	34.5	21.0	20.0	20.0	20.0	20.0	20.0	23.0	23.0	18.0	18.0	18.0	18.0	20.0	20.0	17.0	17.0	14.0	16.0	13.0	14.0	11.0	10.0	9.0	9.0	11.0
North Bound	Name	P27R	P28R	P29R	P30R	P31R	P32R	P33R	P34R	P35R	P36R	P37R	P38R	P39R	P40R	P41R	P42R	P43R	P44R	P45R	P46R	P47R	P48R	P49R	P50R	P51R	P52R	
	Type	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	T	T	T	T	T	T	
	Height	35.0	34.5	21.0	20.0	20.0	20.0	20.0	20.0	23.0	23.0	18.0	18.0	18.0	18.0	20.0	20.0	17.0	17.0	14.0	16.0	13.0	14.0	11.0	10.0	9.0	9.0	

PACKAGE 2 (Gia Lam Section) STA 9+302.5 to STA 12+831.9

GIA LAM ROAD BRIDGE

South Bound / North Bound	Name	A1	A2
	Type	⊥	⊥
	Height	11.7	11.7

CAU BAY CANAL BRIDGE

South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	A2L
	Type	⊥	T	T	T	T	I	⊥
	Height	9.5	7.5	6.1	5.9	6.3	7.8	9.5
North Bound	Name		P1R	P2R	P3R	P4R		A2R
	Type		I	T	T	I		⊥
	Height		5.1	6.2	6.3	7.8		9.5

NH No.5 INTERCHANGE RAMP BRIDGE

Ramp-A	Name	A1A	P1A	P2A	P3A
	Type	⊥	T	T	T
	Height	11.0	11.0	12.0	12.0
Ramp-B	Name	A1B	P1B	P2B	
	Type	⊥	T	T	
	Height	11.0	11.0	11.0	

Note: Height in this table shows height from the bottom of footing to the top of pier.

NATIONAL HIGHWAY NO.5 FLYOVER

South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7L	P8L	P9L	P10L	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	A2
	Type	⊥	T	T	T	T	T	T	T	T	TT	TT	TT	TT	TT	TT	TT	TT	TT	TTT	TTT	T	T	⊥
	Height	11.0	9.0	9.0	10.0	11.0	11.0	12.0	12.0	12.0	13.0	13.0	13.0	12.0	10.0	11.0	12.0	11.0	11.0	11.0	10.0	11.0	10.0	12.0
North Bound	Name		P1R	P2R	P3R	P4R	P5R	P6R	P7R	P8R	P9R	P10R	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R	
	Type		T	T	T	T	T	T	T	T	T	T	T	T	T	TT	TT	TTT	TTT	TTT	T	T	T	
	Height		9.4	9.4	10.4	11.4	11.4	12.4	12.4	12.4	13.4	13.4	13.5	12.4	10.4	11.4	12.0	11.0	11.0	11.0	10.2	11.0	10.0	

PACKAGE 3 (Thanh Tri Section) STA 0+000.0 to STA 6+218.5

PHAP VAN VIADUCT

South Bound	Name	P18L	P17L	P16L	P15L	P14L	P13L	P12L	P11L	P10L	P9L	P8L	P7L	P6L	P5L	P4L	P3L	P2L	P1L	A1
	Type	TT	TT	TTT	TTT	T	T	T	TTT	TTT	TTT	TT	T	T	T	T	T	T	T	⊥
	Height	12.8	12.8	12.8	11.8	12.8	12.8	12.8	12.4	12.4	12.8	12.3	11.8	11.3	10.8	8.8	7.8	7.8	6.8	9.0
North Bound	Name	P18R	P17R	P16R	P15R	P14R	P13R	P12R	P11R	P10R	P9R	P8R	P7R	P6R	P5R	P4R	P3R	P2R	P1R	
	Type	T	T	T	T	T	T	T	TTT	TTT	TTT	TTT	TT	TT	TT	TT	TT	TT	T	
	Height	11.9	12.5	12.8	12.8	12.8	12.8	12.8	12.4	12.4	12.4	11.8	11.3	11.3	11.3	8.3	7.6	7.8	6.6	

PHAP VAN CAU GIE INTERCHANGE RAMP BRIDGE

A-Ramp	Name	Aa1	Pa1	Pa2	Pa3	Pa4	Pa5		
	Type	⊥	T	T	T	T	T		
	Height	11.5	10.3	11.3	11.8	12.3	12.8		
C-Ramp	Name	Ac1	Pc1	Pc2	Pc3	Pc4	Pc5	Pc6	Pc7
	Type	⊥	T	T	T	T	T	T	TT
	Height	10.5	8.3	9.0	11.8	12.5	12.9	12.8	11.3

B-Ramp	Name	Ab1	Pb1	Pb2	Pb3	Pb4	Pb5	Pb6
	Type	⊥	T	T	T	T	T	T
	Height	11.5	10.8	11.8	11.8	12.3	12.8	12.8

KIM GUU RIVER BRIDGE

South Bound	Frontage Road	Name	A1FL	P1FL	P2FL	A2FL
		Type	⊥	T	T	⊥
		Height	7.8	6.5	6.5	7.8
	Throughway	Name	A1C	P1L	P2L	A2C
		Type	⊥	T	T	⊥
		Height	6.5	6.4	6.4	6.5
North Bound	Throughway	Name		P1R	P2R	
		Type		T	T	
		Height		6.4	6.4	
	Frontage Road	Name	A1FR	P1FR	P2FR	A2FR
		Type	⊥	T	T	⊥
		Height	6.4	6.5	6.5	6.4

NGUYEN TAM TRINH BRIDGE

South Bound / North Bound	Name	A1	A2
	Type	⊥	⊥
	Height	11.3	11.3

LINH NAM BRIDGE

South Bound / North Bound	Name	A1	A2
	Type	⊥	⊥
	Height	12.0	12.0

Legend: Types of piers and abutments are listed below.

- T Hammerhaed pier
- TT 2 column pier
- TTT 3 column pier
- I Solid wall pier
- ⊥ Cantilever wall abutment

The number of Piers and Abutments

Package 1		
Abutment	Cantilever Wall	2
Pier	Hhummer Head	27
	2 Column	-
	3 Column	-
	Solid Wall	78
	Sub-total	105

Package 2		
Abutment	Cantilever Wall	9
Pier	Hhummer Head	37
	2 Column	11
	3 Column	5
	Solid Wall	3
	Sub-total	56

Package 3		
Abutment	Cantilever Wall	14
Pier	Hhummer Head	43
	2 Column	10
	3 Column	9
	Solid Wall	-
	Sub-total	62

TOTAL		
Abutment	Cantilever Wall	25
Pier	Hhummer Head	107
	2 Column	21
	3 Column	14
	Solid Wall	81
	Sub-total	223
GRAND TOTAL		248

(2) Foundations

Due to the soft soil condition in this project area, pile foundations are required for all foundations of the proposed bridges. All piles have been designed as a bearing piles in which the tip is to be located into the bearing layer in order to carry the applied loads. The gravel layer which is located at around 40 m below the existing ground has been defined as a bearing layer in this project based on the boring data.

Cast-in-place bored concrete pile has been proposed for all piles and the following diameters of piles were adopted based on comparative study on pile types.

- D = 1.0m should be used for piers which support the superstructure of prestressed concrete I-girder.

- D = 1.5m should be used for piers which support the superstructure of prestressed concrete box-girder and all abutments.

- D =2.0m should be used for piers of Main Bridge of the Red River Bridge so as to support a huge structure.

Table 6.7 shows the result of foundation design in this project by listing required pile length and number with applied boring data.

In this project, it was necessary to take into account the influence of scour on piers of the main Red River Bridge. Estimated depth of scour based on hydrological study is 8.5m below the existing river bed. Maximum scored depth of EL–11.92m was therefore estimated based on the lowest river bed elevation of –3.42m. Piles of the main Red River Bridge were therefore designed as projecting piles which have no resistance against horizontal forces within the section between the bottom of footing and EL-11.92.

Table 6.7 List of Proposed Piles in the Project

PACKAGE 1 (Red River Bridge) STA 6+218.5 to STA 9+302.5

RED RIVER BRIDGE

Approach Bridge 2(T) (A1–P7aL), Thanh Tri Dyke Bridge (P7bL–P10L)

		Approach Bridge 2(T)								Thanh Tri Dyke Bridge			
South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7aL	P7bL	P8L	P9L	P10L
	D	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5
	L	47.0	47.0	46.0	46.0	46.0	46.0	46.0	46.0	45.0	44.0	41.0	42.0
	n	20	8	8	8	8	8	8	8	8	20	20	16
North Bound	Name		P1R	P2R	P3R	P4R	P5R	P6R		P7R	P8R	P9R	P10R
	D		1.0	1.0	1.0	1.0	1.0	1.0		1.5	1.5	1.5	1.5
	L		47.0	46.0	46.0	46.0	46.0	46.0		45.0	44.0	41.0	42.0
	n		8	8	8	8	8	8		8	20	20	16

		Approach Bridge 1(T)											Main Bridge				
South Bound	Name	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	P22LR	P23LR	P24LR	P25LR	P26LR
	D	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0
	L	42.0	42.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	32.0	32.0	29.0	30.0	34.0	34.0	32.0
	n	8	8	8	8	12	8	8	8	8	16	16	36	64	49	64	36
North Bound	Name	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R					
	D	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5					
	L	42.0	42.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	32.0	32.0					
	n	8	8	8	8	12	8	8	8	8	16	16					

Approach Bridge 1(G) (P27L–P43L), Gia Lam Dyke Bridge (P44L–P47L), Approach Bridge 2(G) (P48L–A2)

		Approach Bridge 1(G)																
South Bound	Name	P27L	P28L	P29L	P30L	P31L	P32L	P33L	P34L	P35L	P36L	P37L	P38L	P39L	P40L	P41L	P42L	P43L
	D	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	L	32.0	32.0	42.0	42.0	42.0	35.0	35.0	35.0	35.0	35.0	35.0	41.0	41.0	41.0	30.0	30.0	30.0
	n	16	8	8	8	8	8	16	8	8	8	8	8	16	8	8	8	8
North Bound	Name	P27R	P28R	P29R	P30R	P31R	P32R	P33R	P34R	P35R	P36R	P37R	P38R	P39R	P40R	P41R	P42R	P43R
	D	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	L	32.0	32.0	42.0	42.0	42.0	35.0	35.0	35.0	35.0	35.0	35.0	41.0	41.0	41.0	30.0	30.0	30.0
	n	16	8	8	8	8	8	16	8	8	8	8	8	16	8	8	8	8

		Gia Lam Dyke Bridge				Approach Bridge 2(G)					
South Bound	Name	P44L	P45L	P46L	P47L	P48L	P49L	P50L	P51L	P52L	A2
	D	1.5	1.5	1.5	1.5	1.0	1.0	1.0	1.0	1.0	1.5
	L	30.0	37.0	40.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0
	n	16	20	20	8	8	8	8	8	8	20
North Bound	Name	P44R	P45R	P46R	P47R	P48R	P49R	P50R	P51R	P52R	
	D	1.5	1.5	1.5	1.5	1.0	1.0	1.0	1.0	1.0	
	L	30.0	37.0	40.0	47.0	47.0	47.0	47.0	47.0	47.0	
	n	16	20	20	8	8	8	8	8	8	

PACKAGE 2 (Gia Lam Section) STA 9+302.5 to STA 12+831.9

GIA LAM ROAD BRIDGE

	Name	A1	A2
South Bound / North Bound	D	1.5	1.5
	L	40.0	40.0
	n	16	16

CAU BAY CANAL BRIDGE

	Name	A1	P1L	P2L	P3L	P4L	P5L	A2L
South Bound	D	1.5	1.0	1.0	1.0	1.0	1.0	1.5
	L	43.0	42.0	43.0	43.0	38.0	38.0	40.0
	n	16	6	6	6	6	12	8
North Bound	Name		P1R	P2R	P3R	P4R		A2R
	D		1.0	1.0	1.0	1.0		1.5
	L		42.0	43.0	38.0	38.0		40.0
	n		12	6	6	12		8

NH No.5 INTERCHANGE RAMP BRIDGE

	Name	A1A	P1A	P2A		
A-Ramp	D	1.5	1.0	1.0		
	L	40.0	40.0	40.0		
	n	6	6	6		
B-Ramp	Name	A1B	P1B	P2B	P3B	
	D	1.5	1.0	1.0	1.0	
	L	40.0	40.0	40.0	40.0	
	n	6	6	6	6	

Note: D shows diameter of pile
L shows length of pile
n shows number of piles

NATIONAL HIGHWAY No.5 FLYOVER

South Bound	Name	A1	P1L	P2L	P3L	P4L	P5L	P6L	P7L	P8L	P9L	P10L	P11L	P12L	P13L	P14L	P15L	P16L	P17L	P18L	P19L	P20L	P21L	A2
	D	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5
	L	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	40.0	40.0	40.0	40.0	47.0	47.0
	n	16	8	8	8	8	8	8	8	9	10	10	10	4	10	10	10	10	10	10	12	9	10	10
North Bound	Name		P1R	P2R	P3R	P4R	P5R	P6R	P7R	P8R	P9R	P10R	P11R	P12R	P13R	P14R	P15R	P16R	P17R	P18R	P19R	P20R	P21R	
	D		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
	L		40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	37.0	37.0	37.0	37.0	37.0	37.0	37.0	40.0	40.0	40.0	40.0	47.0	
	n		8	8	8	8	8	8	8	8	8	8	9	4	9	10	10	10	10	10	8	9	9	

PACKAGE 3 (Thanh Tri Section) STA 0+000.0 to STA 6+218.5

PHAP VAN VIADUCT

South Bound	Name	P18L	P17L	P16L	P15L	P14L	P13L	P12L	P11L	P10L	P9L	P8L	P7L	P6L	P5L	P4L	P3L	P2L	P1L	A1
	D	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5
	L	39.0	39.0	39.0	39.0	39.0	39.0	39.0	40.0	40.0	42.0	38.0	38.0	38.0	38.0	40.0	40.0	40.0	40.0	40.0
	n	13	13	10	10	9	9	9	16	16	10	15	15	12	9	9	8	8	8	18
North Bound	Name	P18R	P17R	P16R	P15R	P14R	P13R	P12R	P11R	P10R	P9R	P8R	P7R	P6R	P5R	P4R	P3R	P2R	P1R	
	D	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
	L	39.0	39.0	39.0	39.0	39.0	39.0	39.0	40.0	40.0	42.0	38.0	38.0	38.0	38.0	40.0	40.0	40.0	40.0	
	n	9	9	9	9	9	9	9	16	16	10	15	13	13	13	13	13	13	9	

PHAP VAN CAU GIE INTERCHANGE RAMP BRIDGE

	Name	Aa1	Pa1	Pa2	Pa3	Pa4	Pa5		
A-Ramp	D	1.5	1.0	1.0	1.0	1.0	1.0		
	L	40.0	40.0	40.0	40.0	40.0	40.0		
	n	18	6	6	6	6	6		
C-Ramp	Name	Ac1	Pc1	Pc2	Pc3	Pc4	Pc5	Pc6	Pc7
	D	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	L	40.0	39.0	39.0	39.0	39.0	39.0	39.0	39.0
	n	9	6	6	6	6	6	6	6

	Name	Ab1	Pb1	Pb2	Pb3	Pb4	Pb5	Pb6
B-Ramp	D	1.5	1.0	1.0	1.0	1.0	1.0	1.0
	L	40.0	40.0	40.0	40.0	40.0	40.0	40.0
	n	18	6	6	6	6	6	5

KIM GUU RIVER BRIDGE

		Name	A1FL	P1FL	P2FL	A2FL
South Bound	Frontage Road	D	1.5	1.0	1.0	1.5
		L	39.0	38.0	38.0	39.0
		n	8	12	12	8
	Throughway	Name	A1C	P1L	P2L	A2C
		D	1.0	1.0	1.0	1.5
		L	39.0	38.0	38.0	39.0
		n	12	8	8	12

		Name		P1R	P2R	
North Bound	Throughway	D		1.0	1.0	
		L		38.0	38.0	
		n		8	8	
	Frontage Road	Name	A1FR	P1FR	P2FR	A2FR
		D	1.5	1.0	1.0	1.5
		L	39.0	38.0	38.0	39.0
		n	8	12	12	8

NGUYEN TAM TRINH BRIDGE

	Name	A1	A2
South Bound / North Bound	D	1.5	1.5
	L	43.0	43.0
	n	16	16

LINH NAM BRIDGE

	Name	A1	A2
South Bound / North Bound	D	1.5	1.5
	L	40.0	40.0
	n	16	16

Total Number and Length

Package 1	
Diameter	Number
D=1.0m	184
D=1.5m	832
D=2.0m	249
Sub-total	1,265

Package 2	
Diameter	Number
D=1.0m	470
D=1.5m	102
Sub-total	572

Package 3	
Diameter	Number
D=1.0m	594
D=1.5m	183
Sub-total	777

Grand Total	
Diameter	Number
D=1.0m	1,248
D=1.5m	1,117
D=2.0m	249
TOTAL	2,614

6.3 Superstructure

(1) Main Bridge

Figure 6.2 shows the selected span arrangement. The main span length of 130m was decided so as to provide sufficient clearance for the navigation channel and the side span length of 80m has been determined considering the need to keep a balance with the main span length.

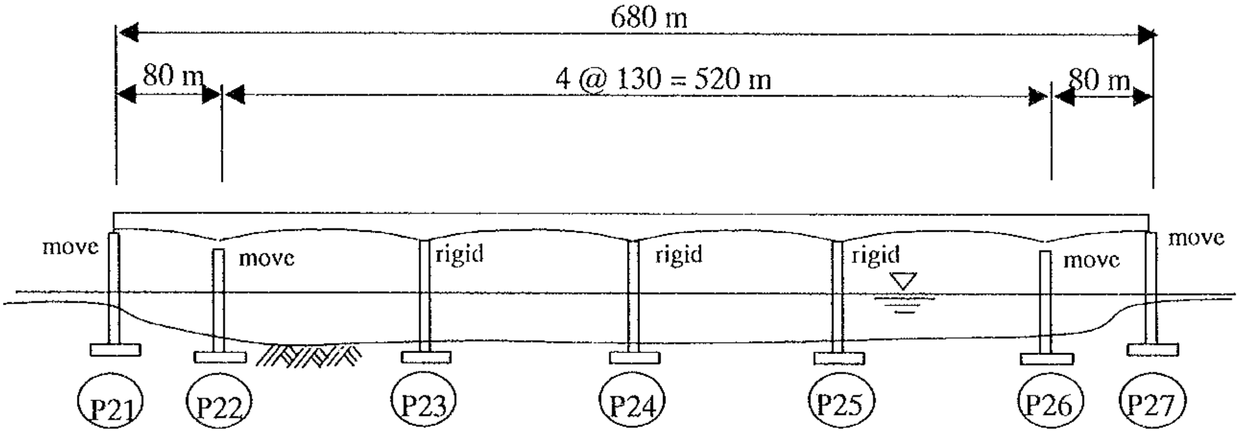


Figure 6.2 Span Arrangement of Main Bridge

Figure 6.3 shows the typical cross-sections. The varying girder height is achieved by parabolic shape of the side-view profile of the bottom slab. The cross-section is a trapezoidal shape with sloping webs and this was selected for aesthetic and economical reasons.

Cast-in-place concrete balanced cantilever construction method is assumed for the design. Considering ease of construction and economy of the form traveller, the maximum weight of a segment is assumed to be 150tf and this results in the segment lengths varying from 2.5m to 4.0m. In the design, the weight of one unit of form traveler is assumed to be 100tf but the contractor will recalculate structural stability using the actual weight of the traveller

(2) Approach Bridge 1

Prestressed concrete box girder bridge is adopted and Figure 6.4 shows the typical cross-section. The girder height of 2.75m is constant throughout the bridge. Trapezoidal cross-section is selected to match for the main bridge's shape.

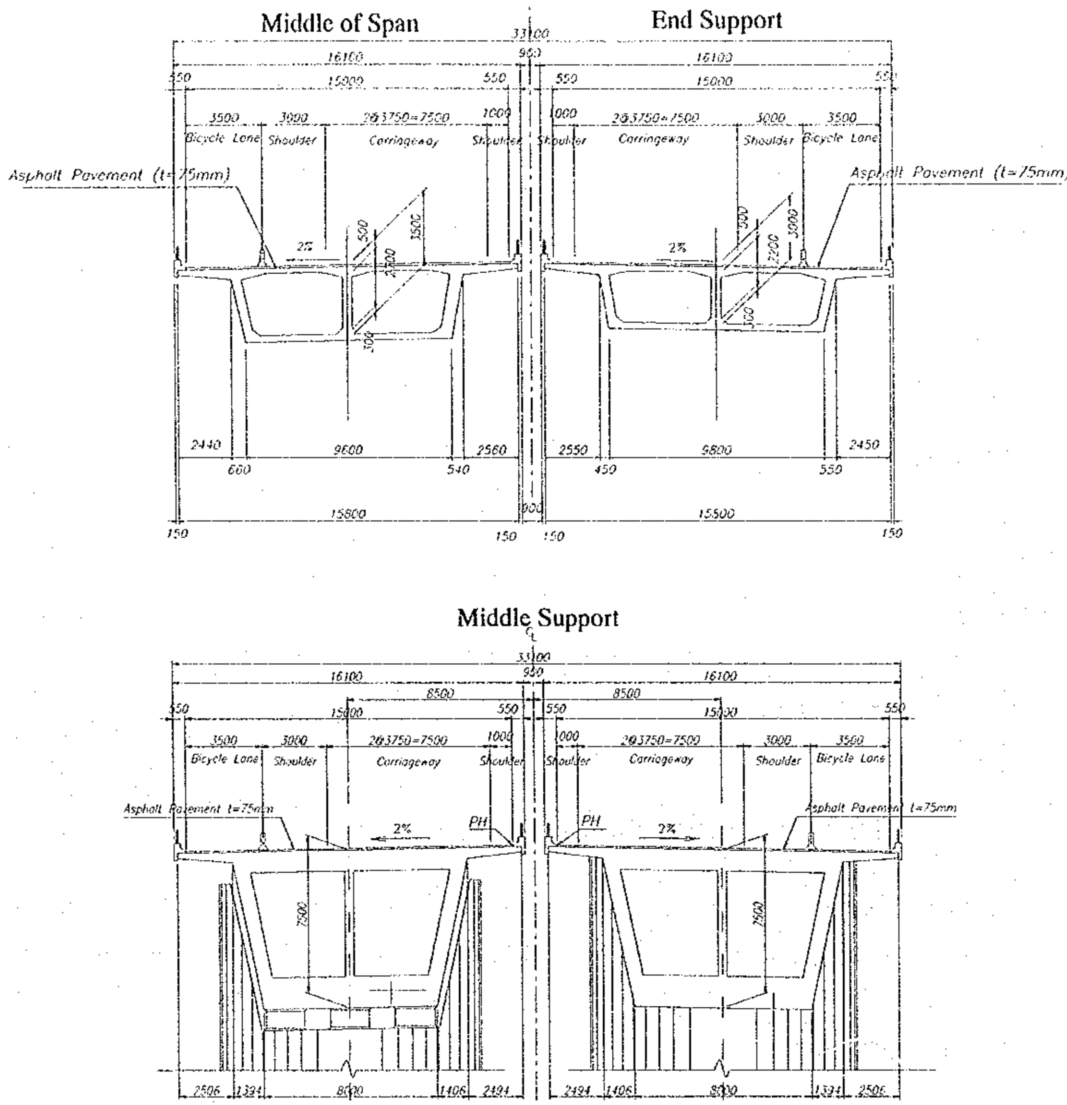


Figure 6.3 Typical Cross-sections of Superstructure of Main Bridge

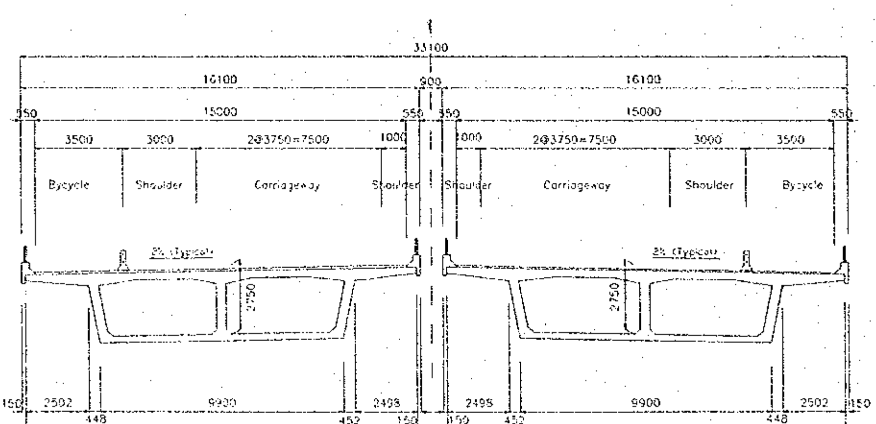


Figure 6.4 Typical Cross-sections of Superstructure of Approach Bridge 1

A comparison study was conducted on the optimum number of continuous spans. A 6-span continuous bridge has been selected as a typical structural type based on considerations for rideability, maintenability and construction economy.

The structural model and assumed construction method are shown in Figure 6.5.

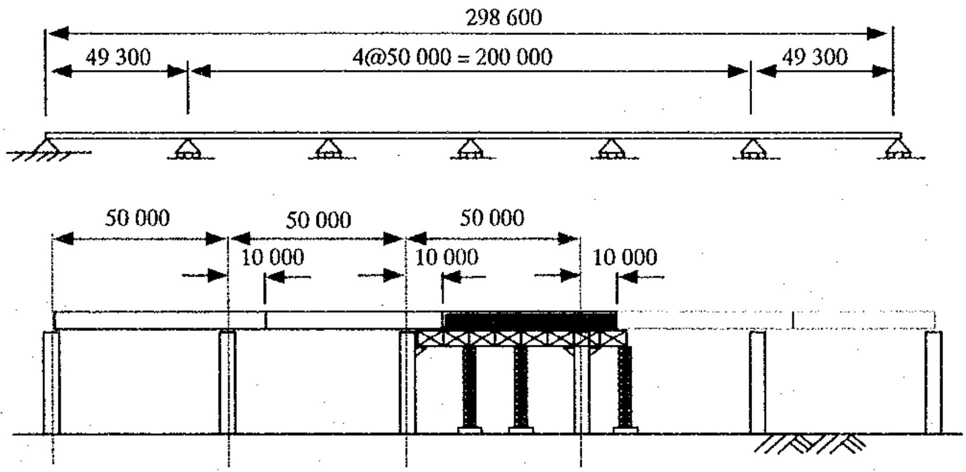


Figure 6.5 Structural Model and Assumed Construction Method for Approach Bridge 1

(3) Approach Bridge 2

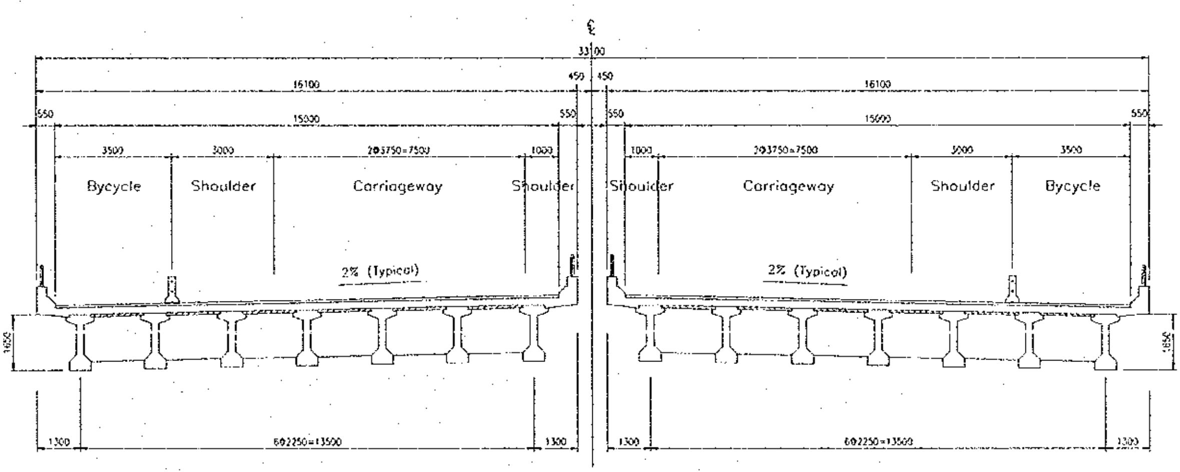


Figure 6.6 Typical Cross-section of Approach Bridge 2

As shown in the typical cross-section in Figure 6.6, precast prestressed concrete I-girder (PC I-girder) bridge will be adopted. The typical girder length of 33.0m was determined for economical reasons. The girder height is 1.65m on which 0.20m thick reinforced concrete deck slab is constructed by cast-in-place concrete. This PC I-girder design utilizes the standard precast girder commonly being used in Viet Nam, therefore, it is economical and timesaving. The bridge is designed as a simple span bridge. The deck slab is continuously connected so as to provide better rideability and maintenability by eliminating expansion joints.

(4) Dyke Bridges

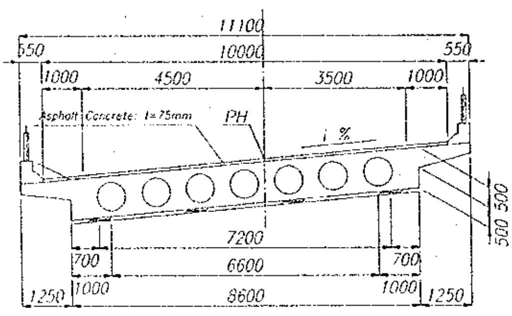
The span arrangement is 80.0 + 130.0 +80.0 (= 290.0m in total)

The main span length of 130.0m has been decided so as not to create hazardous conditions for the existing dyke and the side span length of 80m has been determined so as to keep in balance with the center span length. The girder shape and the design procedures are similar to those of the main bridge.

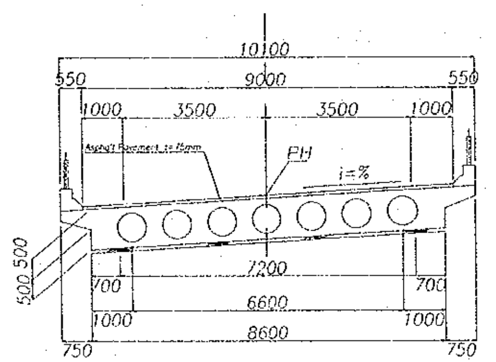
(5) Ramp Bridges

Figure 6.7 shows the typical cross-section. Reinforced concrete hollow slab is adopted for the ramp bridges for the following reasons

(i) small radius of horizontal road alignment . (approximately 50 to 60m)
(ii) span length is 15 to 20m to fit the road alignment, and
(iii) varying road width



(a) A-ramp Bridge



(b) B-ramp and C-ramp Bridges

Figure 6.7 Typical Cross Sections of RC Hollow Slabs of Ramp Bridges

Prestressed concrete bridge will not be feasible because of the irregular shape.

(6) Other Bridges

For economical reasons, PC I-girder with the standard span of 33.0m is basically adopted for other bridges. Refer to Figure 6.6 for the typical cross-section (Note that the roadway width varies depending on the location.) . The girder lengths are changed as appropriate to the ground use conditions. Five different types are used. The lengths and heights, excluding the RC deck, are shown in Table 6.8.

Table 6.8 Types of PC I-girders

Type	length (m)	height (m)	note
Type A	35.0	1.75	1. Type B is the standard type. 2. Girder heights of Types D and E have been determined by the aesthetics to match the adjacent girder height.
Type B	33.0	1.65	
Type C	28.0	1.50	
Type D	28.0	1.65	
Type E	20.0	1.65	

At several locations, the span length had to increase to 50m to satisfy the local conditions. For these bridges, prestressed concrete box girder bridge with the constant girder height of 2.75m is adopted. These bridges are listed in Table 6.9.

Table 6.9 PC Box Girder Bridges (simple span & 2-span continuous)

bridge name	bridge length (m)	span length (m)	note
Nguyen Tam Trinh Bridge	50.0	48.6	
Linh Nam Bridge	50.0	48.6	68° skewed
Cau Bay Canal Bridge	50.0	48.6	combination of PC I-girder and PC box girder bridges
	100.0	49.3 +49.3	

The typical cross-section of these bridges is shown in Figure 6.8.

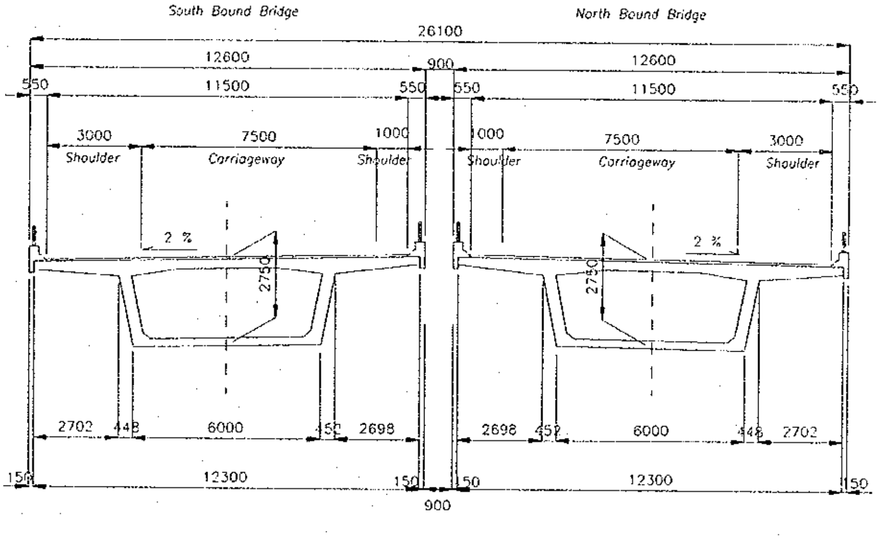


Figure 6.8 Typical Cross-section of PC Box Girder Bridge (simple span & 2-span continuous)

7. DETAILED DESIGN OF BOX CULVERT AND RETAINING WALL

7.1 Box Culvert

The total number of proposed box culverts in this project is eighteen. A breakdown by function of the numbers of box culverts is four box culverts for the canal, six for the pedestrian underpass and eight for the vehicle underpass. Four box culverts are proposed in Package 2 and fourteen in Package 3. There is no box culvert structure in Package 1. Locations and approximate dimensions of these culverts are listed in Table 7.1.

Table 7.1 List of Box Culverts in the Project

Package	Box Culverts No.	Function	Location STA	Reference Road of STA	Crossing Angle (degree)	Inner Dimensions B (m)	H (m)	L (m)	Elavation of Top of Lower Slab (m)	Max. Overlay (m)
Package 3	3BX- 1	Canal	STA 0 +517.000	Frontage-R	90.000 deg.	4.00	2.50	39.50	GL +2.500 ~ +2.500	6.88
	3BX- 2	Canal	STA 0 +510.000	Frontage-L	90.000 deg.	4.00	2.50	39.50	GL +2.500 ~ +2.500	7.12
	3BX- 3	Vehicle	STA 0 +550.080	Frontage-R	90.000 deg.	2@8.75	5.00	17.10	GL +5.568 ~ +5.488	0.00
	3BX- 4	Vehicle	STA 0 +555.852	Frontage-L	88.000 deg.	2@9.25	5.00	19.80	GL +5.753 ~ +5.636	1.10
	3BX- 5	Pedstrian	STA 1 +900.000	Throughway	90.000 deg.	4.00	3.00	26.50	GL +5.820 ~ +5.750	0.00
	3BX- 6	Pedstrian	STA 2 +310.000	Throughway	90.000 deg.	4.00	3.00	29.29	GL +6.119 ~ +5.782	0.00
	3BX- 7	Canal	STA 2 +397.461	Throughway	77.000 deg.	4.00	2.50	93.00	GL +2.500 ~ +2.500	6.38
	3BX- 8	Vehicle	STA 3 +439.380	Throughway	49.376 deg.	8.00	4.00	11.50	GL +6.448 ~ +5.319	0.00
	3BX- 9	Vehicle	STA 3 +965.690	Throughway	47.500 deg.	5.00	4.00	39.03	GL +6.436 ~ +5.746	0.00
	3BX- 10	Pedstrian	STA 4 +503.455	Throughway	74.340 deg.	4.00	3.00	27.52	GL +6.480 ~ +5.429	0.00
	3BX- 11	Vehicle	STA 4 +820.000	Throughway	90.000 deg.	5.00	4.00	26.50	GL +6.873 ~ +6.184	0.00
	3BX- 12	Canal	STA 4 +890.300	Throughway	90.000 deg.	2.00	2.00	104.00	GL +2.500 ~ +2.500	6.50
	3BX- 13	Pedstrian	STA 5 +120.000	Throughway	90.000 deg.	4.00	3.00	26.50	GL +6.868 ~ +5.728	0.00
	3BX- 14	Vehicle	STA 6 +164.890	Throughway	76.753 deg.	5.00	4.00	48.08	GL +6.271 ~ +5.780	0.00
Package 2	2BX- 1	Pedstrian	STA 9 +900.000	Throughway	90.000 deg.	4.00	3.00	26.50	GL +5.239 ~ +4.974	0.00
	2BX- 2	Vehicle	STA 0 +224.300	On Ramp	90.000 deg.	5.00	4.00	11.50	GL +5.636 ~ +5.406	0.00
	2BX- 3	Vehicle	STA 0 +225.960	Off Ramp	90.000 deg.	5.00	4.00	11.50	GL +5.074 ~ +4.844	0.00
	2BX- 4	Pedstrian	STA 10 +550.000	Throughway	90.000 deg.	4.00	3.00	16.00	GL +5.028 ~ +4.763	0.00

7.2 Retaining Walls

Retaining walls are installed in a section of 105.8 m from STA 306.9 until STA 412.7 and the typical cross section of this road section is shown in Figure 7.1.

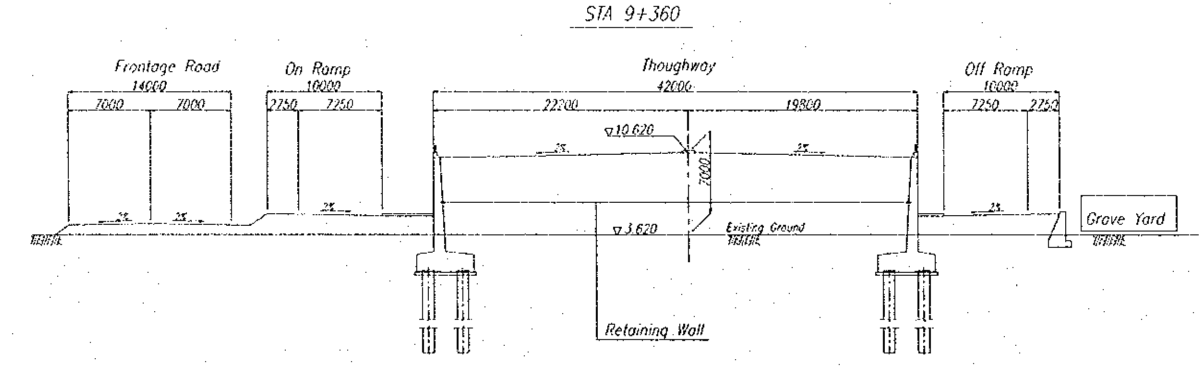


Figure 7.1 Typical Cross Section of Part with Retaining Wall

Retaining walls were designed by the following design criteria:

(1) Concrete Class : Class C – 4 (f'c = 290 kgf/cm^2)
(2) Live Load : q = 1.0 tf/m2
(3) Foundation : Pile foundation
(4) Pile : Cast-in-place bored RC pile, diameter of 1.0m
(5) Soil condition : Applied boring data is BH-B16.

Dimensions of retaining wall and pile arrangement shown in Figure 7.2 were decided based on the design calculation.

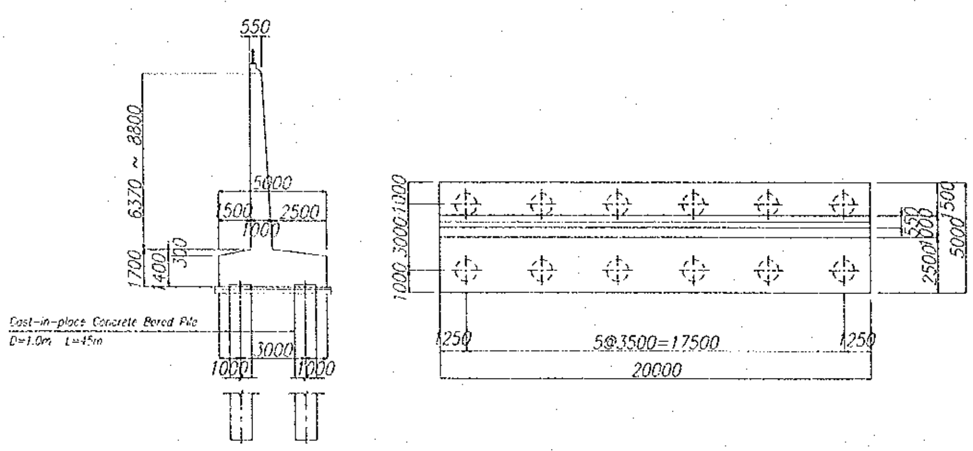


Figure 7.2 Dimensions and Pile Arrangement of Retaining Wall

8. DETAILED DESIGN OF DRAINAGE SYSTEM

8.1 Highway Drainage System

The highway drainage system is primarily intended to carry the rainfall runoff from the surface of the bridge, the road and the embankment slopes. However, it must also carry the runoff which flows into the road area from upstream catchment area and the road surroundings eg. residential areas, farmland, etc.

Consequently the appropriate drainage facilities such as drainage channel, catch basin and road crossing to drain out such runoff smoothly to the downstream were planned in / along the throughway and frontage road to ensure the safety for vehicles and pedestrians and also the stability and function for the roads and bridges.

8.2 Rainfall

The rainfall used for calculating the runoff discharge, is the one-day rainfall for a 10 year return period (215mm /day). This rainfall was also applied for the road crossing culverts designed to drain out the runoff from the upstream catchment area. The rainfall intensity is calculated on the basis of Rziha's formula and its time of flood concentration, and finally the runoff discharge was calculated using the Rational formula by considering the catchment area and runoff coefficients.

For the drainage facilities to be installed in / along the road, it is assumed that the time of flood concentration is 5 minutes in consideration of the figures of the past road projects and conventional figures. The rainfall intensity for the 3 year return period is calculated using the formula developed by Ministry of Construction, Vietnam, and finally the runoff discharge was calculated using the Rational formula in the same way as above.

8.3 Drainage Facilities Designing

The drainage network and condition of flooding at the site were investigated in detail and after they had been confirmed, the drainage facilities design was carried out especially for the road crossings and road side drains.

The proposed drainage facilities based on the design were discussed with local people directly at the site. Based on these discussions and the proper location, dimension and type of drainage facilities were finally decided.

Recognition of the existing drainage condition at the site through the diligent investigation and its major consideration in the design of the proposed drainage facilities is necessary for the following reasons:

(1) Since most of the channels at the site are also utilized as irrigation channel, it is the principal that the existing drainage network should not be changed drastically.

(2) Road crossing is planned where the existing channels are cut off by the road embankment. In addition, at the place where the existing channel network is changed on the downstream side after crossing the road, the basin with stop log is introduced to be able to utilize as irrigation channel as well.

(3) Existing ponds have been naturally functioned as retarding basins and are connected to each other through channels as a part of the drainage network. In this context, road crossing is planned at places where the pond is cut by road embankment.

(4) Farmland has the function of retarding basin as the rainfall runoff is retained on the farmland temporarily. Accordingly the runoff intensities from paddy field and upland field were fixed considering the function of retarding basin and the different cultivation conditions.

(5) The results of the site investigation regarding flooding condition on the planned road alignment, the formation of the existing / on going major road projects and the controlled water height of regulation reservoir of Drainage Project for Environment Improvement were reflected in deciding the road formation level.

9. DETAILED DESIGN OF ELECTRICAL FACILITIES

9.1 Road Lighting

The Thanh Tri Bridge Project comprises Bridge section and at grade approach section. Basically road lights are installed at the at-grade approach road and on bridge road. Electrical power will be supplied from the local electrical power company and for the Thanh Tri Bridge project, this is Hanoi Power Company.

Required characteristics of the electricity utilized for the road lighting are:

- 3 phase 4 wires systems, 380 / 220 volts, 50 Hz AC,
- Demand factor input greater than 0.6,
- Minimum capacity: 50 kVA for Bridge section, and others 31.5 kVA for both bridge,
- Spacing of transformers to be less than 1 km as Medium voltage lines network, and
- Transformers and Distribution to be installed at each electrical power supply point.

9.2 Toll Plaza

A toll plaza is to be installed near Linh Nam Interchange at the Thanh Tri side. The toll plaza includes facilities of tollgates, booths and buildings.

Salient features of the toll plaza are:

<u>Toll gate</u>

- Roof area: 462m^2
- Number of lane islands: 5
- Separator wall: 2
- Number of booths: 5 (Single type and dual type 1)

<u>Toll and road management building</u>

- Floor area; 779 m^2

9.3 Toll Collection System

At the toll plaza the vehicles must stop in order for toll fees to be collected. Attention must therefore be paid to the design with the aim of allowing smooth stopping and traffic flow. Warning should be given to drivers to recognize the existence of the toll facility and the number of tollgates should have enough capacity for peak hour traffic volume.

There is no applicable local design standard to selection of number of lanes at toll facilities and therefore the study team decided to apply design standards of the Japan Highway Public Corporation as this has been commonly employed in Vietnam in the past.

Semi automatic type of toll collecting system has already been employed at National Highway No.1, Chuong Duong Bridge and this type of toll collecting system is recommended instead of the existing manual collection system. The toll collection system is modeled as Figure 9.1.

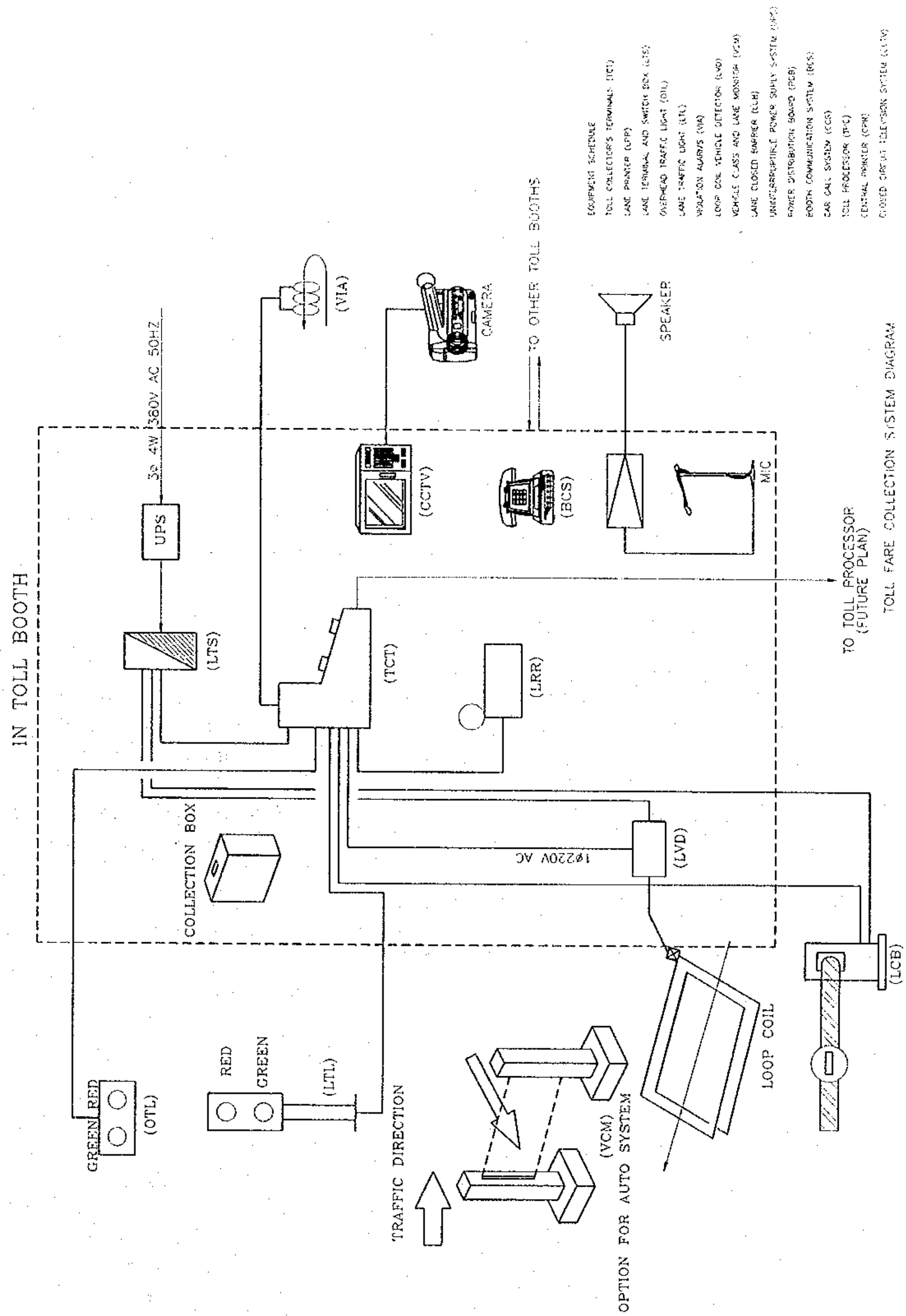


Figure 9.1 Toll Collection System

9.4 Traffic Signals

Traffic signals are provided for the orderly movement of traffic by alternatively allowing platoons of traffic to enter an intersection from different directions. Besides improving the capacity of the intertsection, traffic signals can also reduce accidents.

Traffic signals are to be installed at the following locations.

- Phap Van Cau Gie
- Nguyen Tam Trinh
- Linh Nam and Thanh Tri
- Gia Lam Dyke
- National Highway No.5

The recommended places of various types of traffic signals are as follow:

Type of Traffic Signal	Place of Intersection
1. Overhead type with tapered pole, for vehicle type – 1	On the left side of traffic on the arterial street at the pedestrian crossing.
2. On post type, for vehicle type – 2	On an arterial street, on each side of the pedestrian crossing.

The selection of the signal equipment is in conformity with 22 TCN 237- 97 which is the regulation and standard of the Ministry of Transport in Vietnam.

10. LAND ACQUISITION, COMPENSATION AND RESETTLEMENT IMPREMENTATION PROGRAM

10.1 Aspects of the Project-affected Persons and Assets

Project-affected Persons: Base on the inventory works conducted by the PCs and authorized boards after approval of the ROW, around 1,200 households (230 in Gia Lam, 970 in Thanh Tri) are affected by the project. There are also an estimated 6,000 Project-affected Persons (PAPs) with1,150 being in Gia Lam and 4,850 in Thanh Tri.

Lands: JICA Study Team estimated the size of project-affected area at around 125.8 hectare (ha) and this includes river and riverbed areas. In summary, around 18.4 ha of residential area including garden and etc., 61 ha of agricultural land, 19 ha of pond and 3.3 ha of land for organizations (mostly state-owned). There are also some public facilities that are affected by the Project.

Structures: The project-affected structures are estimated at around 990 (190 in Gia Lam and 800 in Thanh Tri) and 60 affected organizations including office buildings, warehouses, etc. (almost all are located in Thanh Tri)

10.2 Policy Framework

Legal Framework:

(1) Government Decree No. 22/1998/ND-CP: On Losses Compensation When Government Withdraw Land to Use for the Purpose of National Defense, Security, National Benefits and Public Benefits.

(2) Ministry of Transport's Decision No. 592/1999/OD-GTVT, which is pursued to Decree No. 22/1998/ND-CP mentioned above: On Procedures and Progress of Land Clearance for the Transportation Construction Works.

(3) Hanoi People's Committee's Decision No. 20/1998/QD-UB, which is pursued to Decree No. 22/1998/ND-CP mentioned above: On Implementation of Decree No. 22 within the Hanoi Area. This Decision shows more detail regulations for some articles of compensation policies in case of Hanoi Metropolitan Area.

Principles and Objectives:

(1) Land acquisition and forced resettlement will be minimized as much as possible.

(2) All families, persons and organizations affected by the Project will be compensated for their lost assets, and supported with subsidies for rehabilitation of their sustenance and relocation.

(3) The compensation and resettlement measures consist of (i) compensation for all lost assets (lands, structures, crops and etc.); (ii) assistance for rehabilitation and relocation with subsidies; (iii) resettlement with suitable infrastructure.

(4) Effective and timely announcement, guidance, survey, planning and consultation for project affected persons, are conducted by respective PCs and authorities in accordance with each implementation step.

(5) All payments related with compensation and resettlement will be paid to the project affected persons before the relocation.

(6) Every effort will be made to prepare resettlement sites at the locations as close as possible from former settlements, and the project affected persons will be resettled based on their former group or community.

(7) Resettlement sites will be prepared with suitable infrastructures including residential road, water supply, power supply, drainage and access road.

Types of Project Affected Persons:

(1) Persons whose assets are partially or fully affected by the Project: land acquisition for ROW, any other infrastructure construction of resettlement sites, and additional land acquisition, if necessary for the Project.

(2) Persons and organizations whose businesses, sustenance or activities are temporarily and permanently affected by the Project.

Entitlement Policy:

(1) Assets: 1) Lands, 2) Structures, 3) Crops, 4) Graves, trees and other assets.

(2) Subsidy: 1) Living assistance for persons, 2) Relocation assistance, 3) Recovering assistance for farmers, 4) Reward policy for households.

(3) Resettlement Sites Preparation: For resettlement, the PAPs would be given options: 1) Cash compensation for land and other assets, and "self-resettlement" to places of their own choice, 2) Cash compensation for dwelling house, other structures and assets, and resettlement at the official Resettlement site.

(4) Restoration of communal infrastructure and utilities: In case where communal infrastructure or utilities are affected, the utilities and lost infrastructure will be restored for the remaining communities.

10.3 Procedure of Land Acquisition and Resettlement

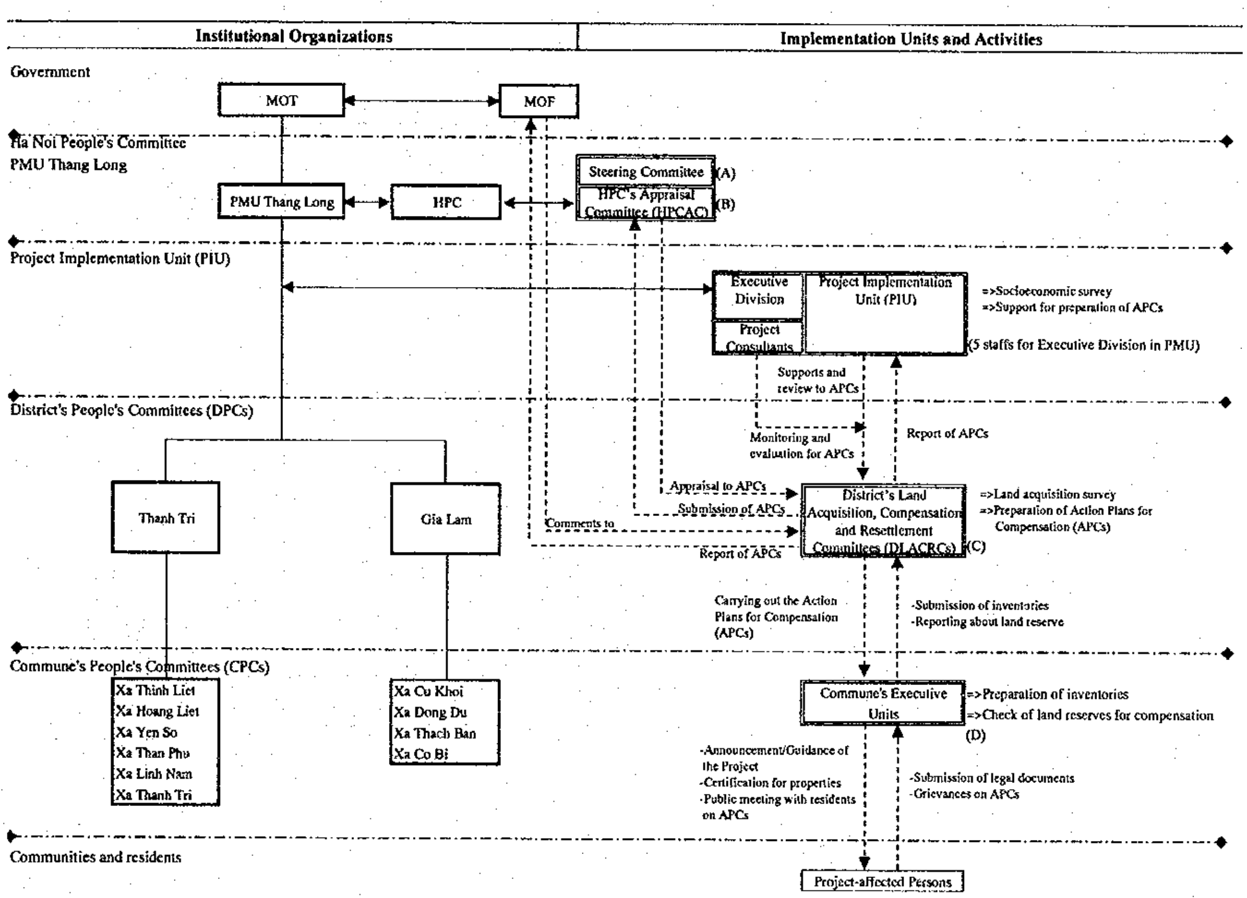
Outline of the procedure:

(1) Establishment of District's Land Acquisition, Compensation and Resettlement Committees (DLACRCs) in Thanh Tri and Gia Lam.
(2) Establishment of Project Implementation Unit (PIU) with project consultants.
(3) Preparation of legal documents by PAPs.
(4) Preparation of Action Plans for Compensation and Resettlement (APCRs) by DLACRCs
(5) Appraisement of the APCRs by HPC's Appraisal Committee (HPCAC).
(6) Implementation of APCRs. Monitoring and Evaluation of the APCRs, if needed.

10.4 Roles and Activities of Participants

The institutional organization, implementation units and activities are summarized and shown in Figure 10.1.

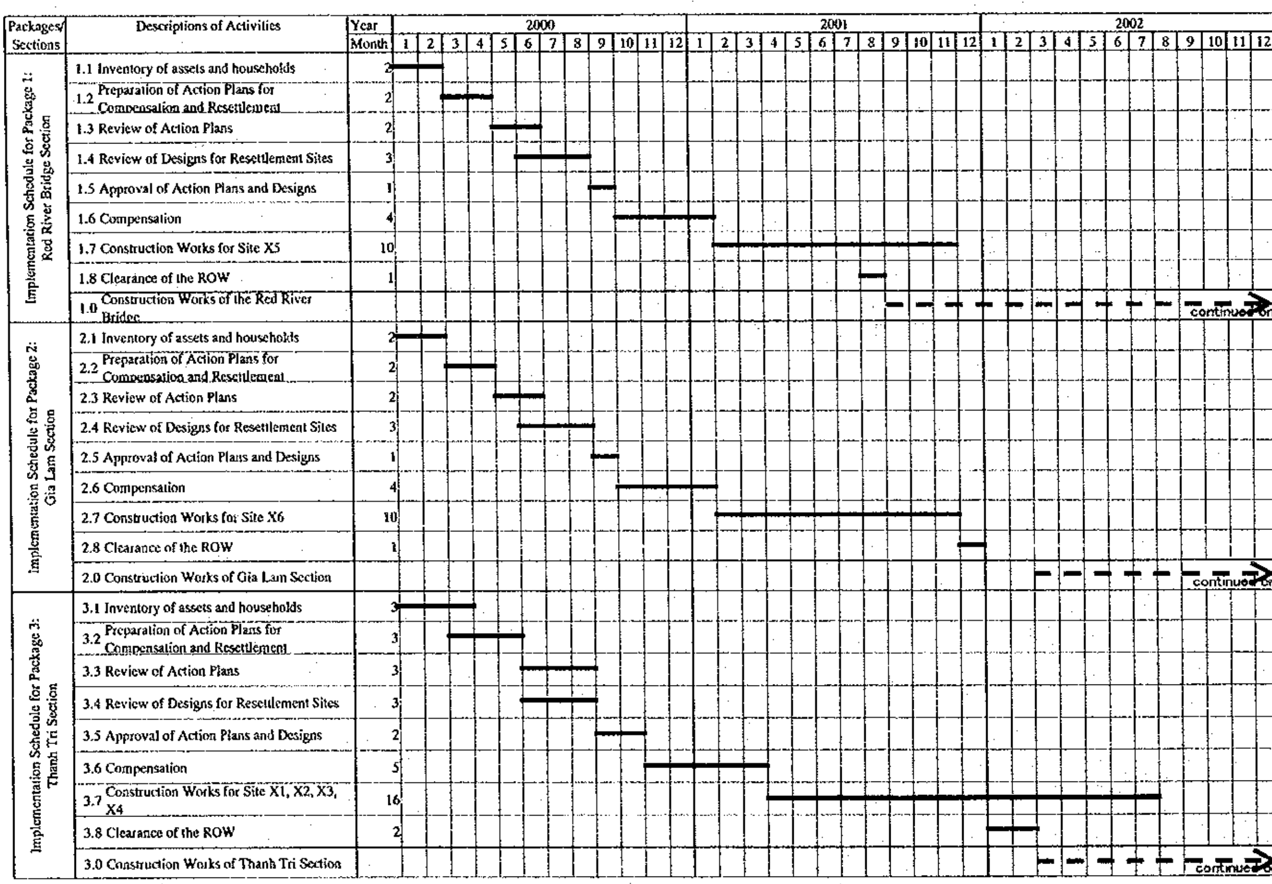
Figure 10.1 Organization Chart and Activities



10.5 Implementation Schedule

In addition to the preparations of inventory and action plans for the PAPs, reviews of action plans and designs of resettlement sites are a necessary part of the implementation procedure. The review of designs of resettlement sites is important in particular because whole data of the PAPs will be based on accurate inventories. The PAPs' intentions for relocation on the resettlement sites also are confirmed in the review works. Furthermore, some additional or supplemental surveys, which include meetings and coordination with related local PCs and HPC are carried out to confirm approval of the designs (See Figure 10.2).

Figure 10.2 Implementation Schedule of Land Acquisition, Compensation and Resettlements



10.6 Compensation Costs

The latest regulations were used as a guideline to estimate costs for land acquisition, compensation for properties' losses and the plan of resettlement sites. However, it was noted that the governments, HPC and authorized boards will decide detail policies in any cases, and execute accurate evaluations in accordance with conditions of each project (See table 10.1).

Table 10.1 Compensation Costs

Compensation Items \ Packages and Sections		Compensation Costs				Notes
		Package 1 Bridge Sec.	Package 2 Gia Lam Sec.	Package 3 Thanh Tri Sec.	Package 4 Resettlement	
(A)Compensation	1) Lands	2,318	22,968	176,195	2,160	
	2) Houses and buildings	2,362	24,675	62,141	0	office buildings included
	3) Crops	930	3,110	6,601	1,800	
	4) Tombs	0	20	0	0	for concrete and soil tombs
	Total	5,610	50,773	244,937	3,960	
(B)Subsidy	5) Living assistance	650	1,238	8,625	0	organizations included
	6) Relocation assistance	450	627	4,035	0	for supporting transfer
	7) Reward policy	500	675	4,350	0	for on scheduled transfer
	8) Recovering assistance	838	4,450	5,663	1,800	for farmers
	Total	2,438	6,990	22,673	1,800	
(C) Restoration of communal infrastructure		805	5,776	26,761	576	10% of (A) + (B)
(D) Compensation total		8,853	63,539	294,371	6,336	(A)+(B)+(C)
(E) Administration costs for compensation		2,012	3,340	10,821	600	for compensation procedure
(F) Relocation sites for organizations		0	997	22,288	0	compensation cost included
(G) Allowance		1,087	6,788	32,748	694	10% of (D)+(E)+(F)
(H) Grand Total		11,951	74,664	360,228	7,630	(D)+(E)+(F)+(G)

11. DETAILED DESIGN OF RESETTLEMENT SITES

11.1. Locations for the Resettlement Sites

HPC proposed six locations for resettlement sites of the Project of which four sites are prepared for Thanh Tri and two sites for Gia Lam (See Figure 11.1). The six sites mean "the resettlements for and by present communal groups". Main reasons of the site selections are summarized as follows:

1) The sites should be located as close as possible to former settlements to sustain: (i) present kinship groups, (ii) daily sustenance system such as mutual help and aids, (iii) linkages with communal properties or facilities.
2) The resettlement plans need to follow the future land use plan of the Hanoi Master Plan made by the HPC.
3) The sites are selected from reserved lands of the HPC or the related PCs as suitable to the both items of 1) and 2) mentioned above, because smoother procedure of compensations and resettlements can be expected on the reserved lands of the PCs.

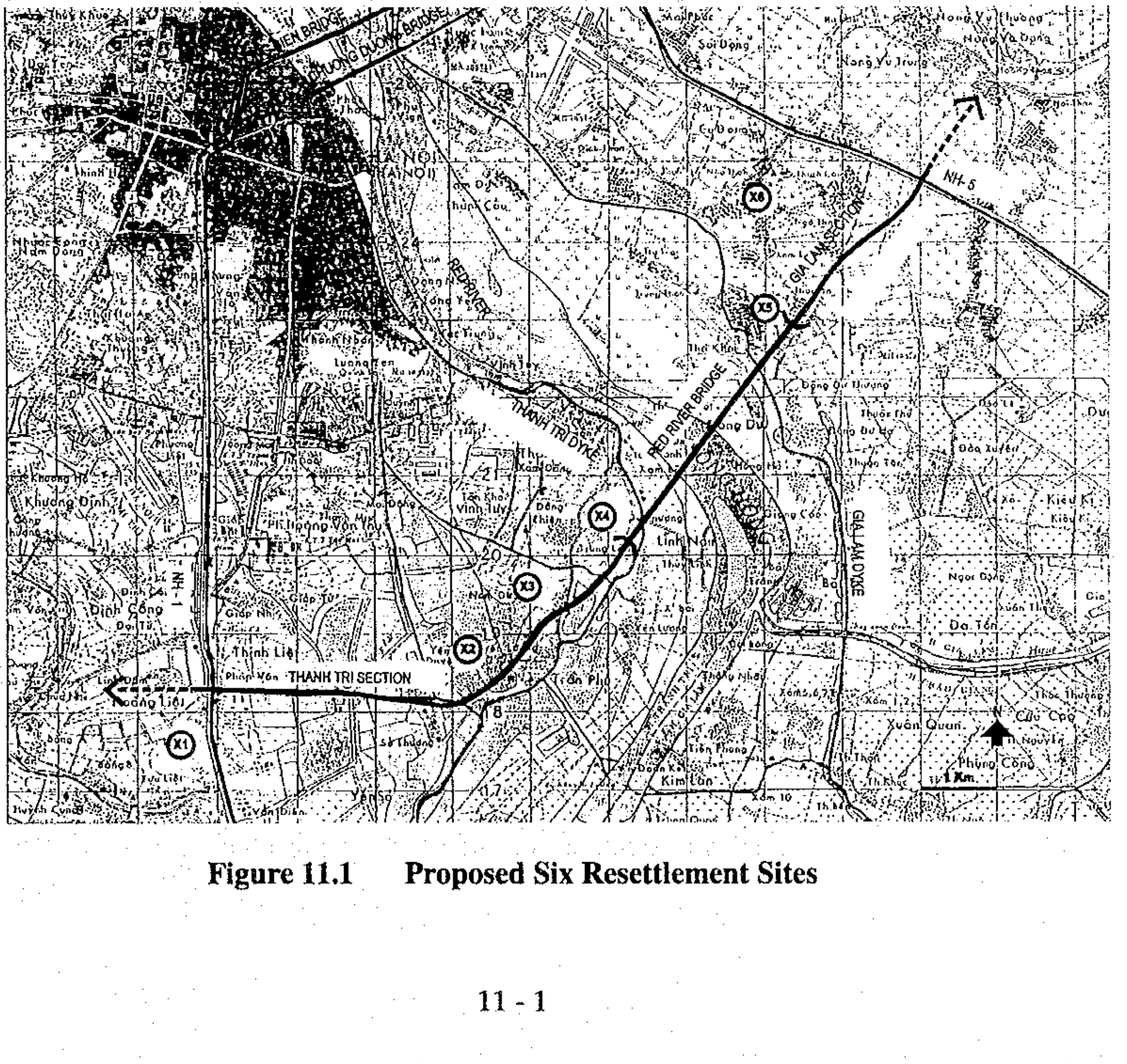


Figure 11.1 Proposed Six Resettlement Sites

11.2. Sizes and Groups of the Resettlement Sites

Accurate sizes of housing lots to be allocated for resettlers in the resettlement sites should be reviewed in accordance with inventories; size of residential lands owned by PAPs. These details are prepared by the respective PCs after approval of the ROW and therefore the Study Team estimated the average size for a household as follows.

Groups to be resettled on a same site should be from the same community or neighborhood. These groups are shown in table below, in accordance with the locations of the resettlement sites mentioned above and present settlements of the PAPs. The size of each site is estimated in Table 11.1 based on the total number of households to be resettled in the site and 100m^2 as the size of each house allocation.

Table 11.1 Size of the Resettlement Sites

District	Location	Name of commune	Sites	Families	Persons	*Size(m^2)
Gia Lam	Along NH5	Thach Ban /Co Bi	X6	130	650	13,000
	Thuong Hoi	Thach Ban				
	Near Gia Lam Dyke	Cu Khoi/Dong Du	X5	100	500	10,000
	Total Gia Lam		2 sites	230	1,150	23,000
Thanh Tri	Along Linh Nam St.	Linh Nam	X4	80	400	8,000
	Nam Du Ha	Tran Phu	X3	170	850	17,000
	Yen Duyen	Yen So	X2	330	1,650	33,000
	Along Phap Van St.	Yen So				
	Along Phap Van St.	Hoang Liet/Thinh Liet	X1	390	1,950	39,000
	Along Phap Van St.	Hoang Liet				
	Northern corner of NH1	Hoang Liet				
	Total Thanh Tri		4 sites	970	4,850	97,000
Total Project			6 sites	1,200	6,000	120,000

Source: JICA Study Team

Notes: * Average 100m^2 for a family includes space for infrastructure

11.3. Required Infrastructures

Restoration or improvement of the living environment is a major policy in the preparation of resettlement sites. Infrastructure and social services should be provided on the resettlement sites to at least the same level as the former conditions. A difference of current condition of infrastructures among affected residential areas, is whether drinking water is supplied by city supply system or not. However, the following infrastructure should be provided at all resettlement sites.

- Drainage
- Power supply
- Water supply
- Residential streets for accesses to residential properties.

11.4. Detailed Design of the Resettlement Sites

Design Standards for Resettlement Sites: The designs should follow the local standards and orientations of the area as given in the Hanoi Master Plan 2020. It is necessary to meet the local social and economic requirements to resettle the project-affected persons and sustain their living environment in the newly constructed area.

Design Policies: The Study Team should follow the local procedure to design the resettlement sites and this includes geological, special coordination with HPC and DPC, confirmation of cadastral condition on the site and coordination with local water / power supply companies. However, six resettlement sites are proposed to match with requirement of the PAPs and this situation makes the procedure of detail design more complicated.

The Study Team therefore selected site number X5 as the model site of resettlement, because the site preparation of X5 will be required in early construction stage of the Thanh Tri Bridge Section. According to a local consultant, the conditions of design and civil works for all sites are quite similar and the Study Team therefore applied the design policies of the X5 site to the other sites. In any case, the detail designs should be reviewed in accordance with inventories of PAPs, which are prepared by respective PCs after approval of the ROW.

(1) Streets: Two access ways are planned for the residents. One street connects to the NH5, which is planned in the Hanoi Master Plan and the other one connects to the frontage road of the SHTRR. Paved residential streets with walkway lot the resettlement site for four blocks at 20-30 houses. Every housing lot faces on to the residential streets to secure suitable accessibility.

(2) Drainage System: Rainy drainage is constructed from reinforced concrete pipe culvert of diameter 400 to 600 mm with manhole and catch basin. Drainage for wastewater is constructed by masonry ditch at either side of inner streets. In the long term, this ditch system is connected to the general drainage system of the surrounding area. This is the expected system for urbanization, but in the short term, the wastewater is discharged into the storm water drainage system.

(3) Water Supply System

1) Water source: Under ground water is available at a shallow level of around 30m isused as the source of water supply for the residents. Capacity of the well is required to be around 6 to $8m^3/h$.
2) Water treatment station: Water treatment station consists of jet rig, a settling tank, filter tank and water tank with capacity of $160m^3$. Potable water is supplied by water service pipe.
3) Structures of the station: Main structures of the station are masonry water treatment station and reinforced concrete tanks.
4) Fire extinguishing: Water reservation tank always keeps 60 m^3 for fire extinguishing.

(4) Power Supply and Lighting System: The 22 KV line is connected from the power supply to the sub-station. Single arm high-voltage lamp is used for lighting and they are connected together by HT 0.4 KV cable.

(5) Planting: Each housing block is planned for landscaped area in the center of the block. These green spaces are very important to make superior living environment for the residents although they have not so large scale.

(6) Public space: Space for public projects is secured on the corner of the site according to the policy of HPC. This space could also satisfy any demand or request for public facilities from the surrounding communities.

12. CONSTRUCTION PLANNING

12.1 Superstructure

(1) Main Bridge

A comparative study was carried out on the following construction methods.

Option I cast-in-situ concrete segmental cantilever erection

Option II precast concrete segmental cantilever erection
Alternative IIa: construction by erection nose
Alternative IIb: construction by launching girder

It has been concluded that Option I will be the most feasible construction method and Figure 12.1 shows the typical construction stage. Table 12.1 shows a sample standard working schedule for one segment. The total required construction period has been estimated to be 48 months including the substructure / foundations and superstructure.

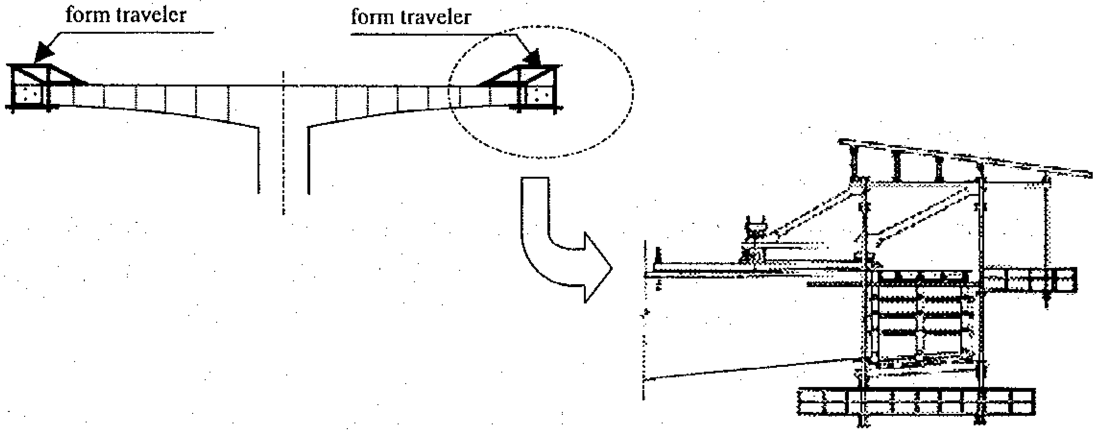


Figure 12.1 Typical Construction Stage of Main Bridge

Table 12.1 Typical Construction Schedule for One Segment

work item \ day	1	2	3	4	5	6	7	8	9
Form Traveler Installation	=								
Formwork, Rebars, PS tendons	=	=	=	=					
Concrete Casting					=				
Curing					=	=	=	=	
Prestressing								=	
Preparation for Traveler Transfer									=

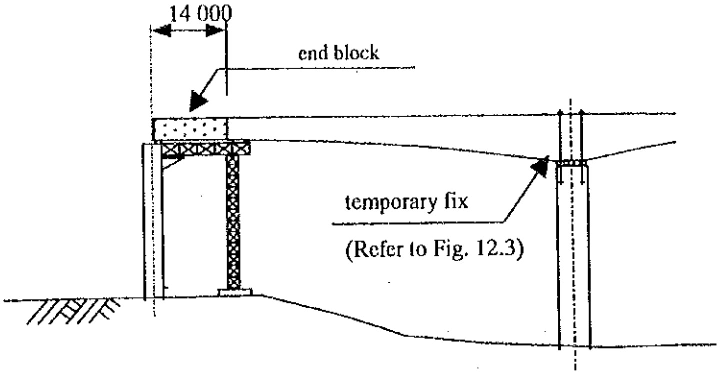


Figure 12.2 Construction of End Block in Side Span

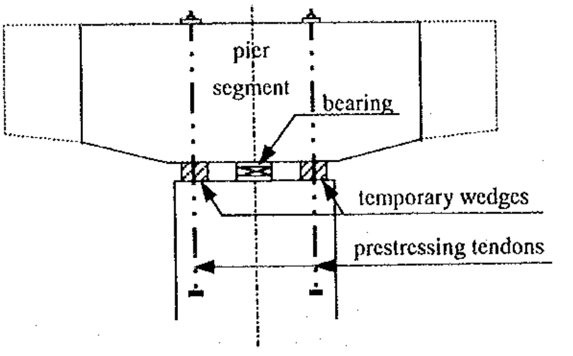


Figure 12.3 Example of Temporary Fixing of Pier Segment

End block of the side span will be constructed on staging and an example of the construction method is given in Figure 12.2.

During the cantilever construction, the girder shall be temporarily fixed to the pier at Piers 22 and 26 so that it possesses adequate resistance to bending. An example of the temporary fixing is shown in Figure 12.3.

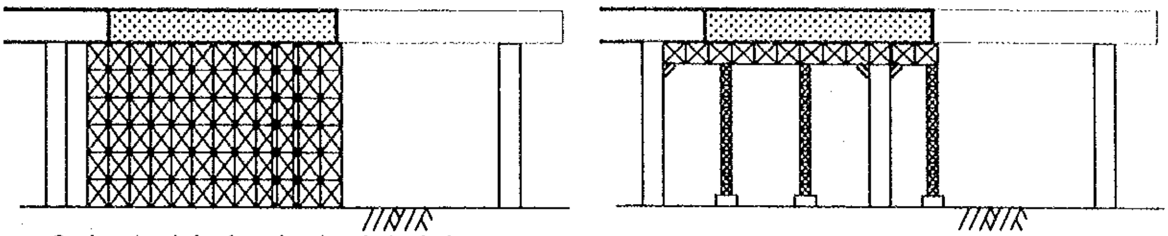
(2) Approach Bridge 1

The bridge consists of prestressed concrete continuous box girders with span length of 50.0m except for one adjustment span of 30.0m. There are various applicable construction methods as follows:

Option I : Erection by launching girder with cast-in-place concrete
Option II : Span-by-span erection on staging, or falsework, with cast-in-place concrete
Option III : Span-by-span erection with precast segments
Option IV : Precast segment cantilever erection with cranes
Option V : Incremental launching

A comparative study was carried out on the above construction methods. It has been concluded that Options I and V will not be feasible because they are more costly than other construction methods. A further study was therefore conducted on Options II, III and IV. It has been concluded that although Option IV may require many work steps with relatively high construction cost, any of these three methods will be feasible. Final decision will be made based on the Contractor's preference.

Examples of construction of PC box girder on staging are given in Figure 12.4.



Option A: girder location is relatively low

Option B: girder location is relatively high

Figure 12.4 Examples of Construction of PC Box Girder on Staging

(3) Approach Bridge 2

This bridge will be constructed by precast prestressed concrete I-girder (PC I-girder), of which the standard girder length is 33.0m. Primary construction conditions to be considered are listed in Table 12.2.

Table 12.2 Primary Construction Conditions of Approach Bridge 2

Total Bridge Length (M) N-bound + S-bound	Clearance Between Girder And Ground	Length (L), Weight (W) And Number (Nos.) Of PC I-Girder
Thanh Tri Side: 226+246	4.5 to 12.5 m	L=20m, W=39.5tf /each --- 7 nos. L=28m, W=53.3tf /each --- 14 nos. L=33m, W=61.5tf /each --- 168 nos.
Gia Lam Side : 198+198	5.5 to 12.5 m	

Under the above conditions, many construction methods are applicable and the following are some examples :

Example 1: Erection by Truck Cranes
Example 2: Erection by Self-driven Portal Frame
Example 3: Erection by Erection Girder

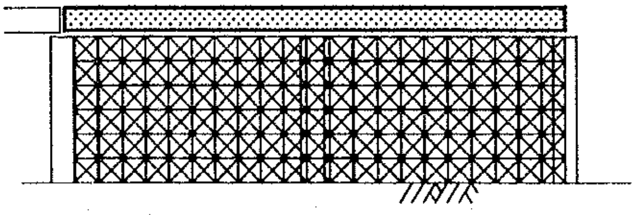
Other than the above methods, there are also various alternative methods. Final selection will be done by the Contractor after considering the location of the fabrication yard and available construction equipment.

(4) Dyke Bridges

This bridge will be constructed by cast-in-place concrete segmental cantilever erection method. The bridge length is 290.0m and the span arrangement is 80+130+80m. Construction of these bridges will be carried out in similar way to the main bridge. Refer to Section 12.1(1) for the detail. Note that temporary fixing of the pier segment is not needed because of the rigid connection.

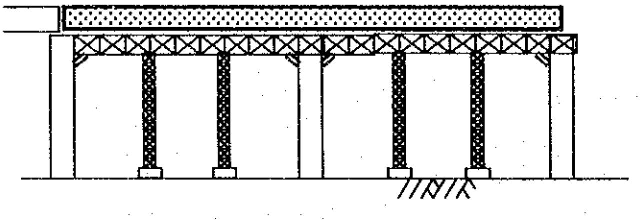
(5) Ramp Bridges

The ramp bridges will be constructed by using cast-in-place reinforced concrete hollow slab. Construction on fixed staging is widely used for this type of bridge. Wide variety of staging types are possible and as examples, two alternatives are shown in Figure 12.5



Alternative 1

on-ground staging



Alternative 2

combination of staging and temporary columns. The columns may be omitted.

Figure 12.5 Construction on Fixed Staging (RC hollow slab)

(6) Other Bridges

1) PC I-girder bridge

Phap Van Viaduct and National Highway No.5 Flyover will be constructed mainly by PC I-girders. Primary construction conditions to be considered are listed in Table 12.3..

Table 12.3 Primary Construction Conditions of Other PC I-girder Bridges

total bridge length (m)	clearance between girder and ground	length (L), weight (W) and number (nos.) of PC I-girder
Phap Van Viaduct: 1,150(total) north bound: 575m south bound: 575m	4.6 to 9.5 m	L=28m, W=50.0tf/ each --- 75 nos. L=33m, W=61.5tf/ each --- 199 nos. L=35m, W=67.5tf/ each --- 58 nos.
NH No.5 Flyover : 1,390(total) north bound: 695m south bound: 695m	5.8 to 10.0 m	L=20m, W=39.5tf/ each --- 20 nos. L=28m, W=50.0tf/ each --- 79 nos. L=33m, W=61.5tf/ each --- 251 nos. L=35m, W=61.5tf/ each --- 16 nos.

Refer to Section 12.1 (3) for applicable construction methods.

2) PC Box girder bridges

Other PC box girder bridges are listed in Table 12.4 and these bridges will be constructed on on-ground fixed staging because of the construction economy. Nguyen Tam Trinh Bridge and Linh Nam Bridge are constructed above existing local roads and during construction, careful measures shall be established for the public safety.

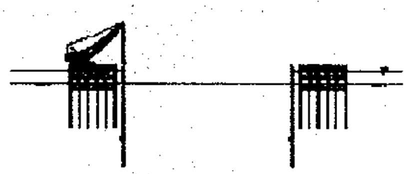
Table 12.4 Other PC Box Girder Bridges

bridge name	bridge length (m)	clearance between girder and ground	notes
Nguyen Tam Thrinh Bridge	50.0	6.2 to 7.0 m	
Linh Nam Bridge	50.0	4.9 to 5.6 m	68° skewed
Cau Bay Canal Bridge	50.0 and 100.0	2.5 to 5.5 m	

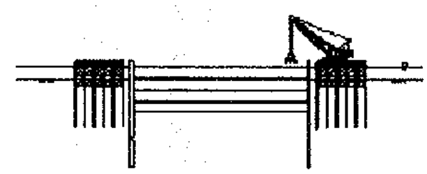
12.2 Substructure and Foundation

(1) Main Bridge

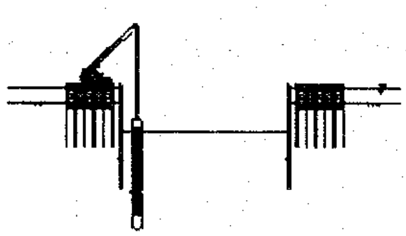
Construction procedures for the foundation and the substructure are schematically shown in Figure 12.6.



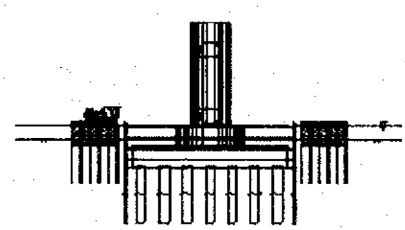
Step 1: Staging construction and Installation of sheet pile



Step 2: Excavation and construction of cofferdam



Step 3: Construction of cast-in-situ concrete piles



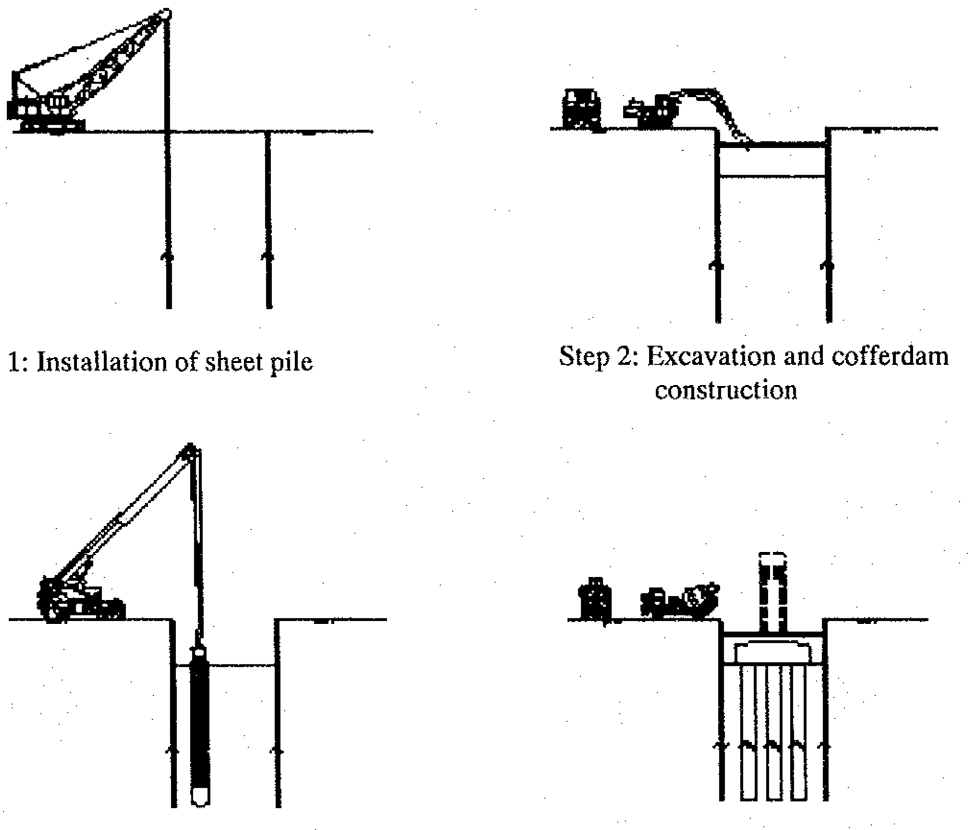
Step 4: Construction of substructure

Figure 12.6 Construction Procedures for Substructure / Foundation for Main Bridge

The cast-in-situ concrete piles are constructed by reverse circulation method and Section 12.2.(2) gives the details.

(2) Approach Bridges

Construction procedures for the foundation and the substructure not located in-water area are schematically shown in Figure 12.7.



Step 1: Installation of sheet pile

Step 2: Excavation and cofferdam construction

Step 3: Construction of cast-in-situ concrete piles

Step 4: Construction of substructure

Figure 12.7 Construction Procedures for Substructure/Foundation for Approach Bridges

Cast-in-situ concrete piles are constructed by reverse circulation method. The construction procedure is as follows;

(i) installation of a stand pile
(ii) excavation
(iii) installation of reinforcing bars
(iv) installation of Tremie pipe
(v) concrete casting
(vi) backfilling

12.3 Construction Schedule

Estimated required construction periods are summarized below;

(1) Package 1 : required total construction period = 48 months

- Approach Bridge 2 (Thanh Tri Side)	19 months
- Dyke Bridge (Thanh Tri Side)	31 months
- Approach Bridge 1 (Thanh Tri Side)	33 months
- Main Bridge	46 months
- Approach Bridge 1 (Gia Lam Side)	36 months
- Dyke Bridge (Gia Lam Side)	31 months
- Approach Bridge 2 (Gia Lam Side)	17 months

(2) Package 2 : required total construction period = 42 months

- National Highway No.5 Flyover	30 months
- NH No.5 Interchange Ramp Bridge	14 months
- Gia Lam Road Bridge	8 months
- Cau Bay Canal Bridge	20 months

(3) Package 3 : required total construction period = 42 months

- Phap Van Viaduct	26 months
- Phap Van Cau Gia Interchange Ramp Bridge	20 months
- Kim Nguu River Bridge	12 months
- Nguyen Tam Trinh Bridge	9 months
- Linh Nam Bridge	9 months

(4) Package 4

Required total construction period for the infrastructure at the settlement area is estimated to be approximately 18 months.

12.4 Soil Stabilization

(1) Sand Drain

1) Requirements of Sand Drain

i) Sand material must be the medium-size grain sand with the following requirement.

- The ratio of grain-size more than 0.5mm should be more than 50%.
- The ratio of grain-size less than 0.5mm should not exceed 10%.
- Permeable coefficient of sand must be more than 10^{-4} m/s.
- Organic content should not exceed 5%.

If the exact properties are not available naturally, it is possible to use coarse sand mixed with gravel (not including crushed Stone).

ii) Sand drain equipment must have the following technical specifications:

- Equipment must have enough force to drive the sand drain casing down to the design depth.
- The driving equipment must be stable and able to work properly in all weather conditions.
- The drilling machine must be equip twisted drilling rod of 400mm in diameter interlinked by bolt.
- Water pump must have more than 2.0m^3/h in capacity.

2) Construction Method

i) It is necessary to design the working procedure of the driven equipment on the site of the sand mat layer in accordance to the following principles:

- When working, the equipment cannot be placed on the head of a constructed sand drain.

ii) Before main construction works, the Contractor must carry out a pilot (sample) construction within the construction scope in which equipment must successfully drive sand drain, at least 2 or 3 times.

- Prior to carrying out a pilot construction. The Contractor shall submit the test procedure and the construction method for approval in written to the Supervision Consultant.

- Thus pilot (sample) construction must be witnessed by Supervision Consultant and during the pilot construction should be observed and checked.
- Checking each construction step and accurately operation of construction of sand drain process (vertical level, position on plan and the depth).

(2) Plastic Board Drain

1) Requirement of Plastic Board Drain

- Permeable coefficient of non-woven geo-textile cover must be 3 to 10 times higher than the permeable coefficient of the adjoining soil layer, however, it must still prevent the small size grains of soil from passing through into the drain.

  $K_{cover} > 1.4 \times 10^{-4}$ m/s
- The pore diameter of cover shall not exceed 0.08mm
- The cover and the core of plastic board drain must not be broken during bearing pressure process in the period of transportation.
- Plastic board drain must have the following characteristics:
  - Tensile strength (whole width of plastic board drain) must not be less than 1.6KN
  - Elongation (with whole width of plastic board) > 20%
  - Elongation with the force 0.5KN < 10%
  - Drain probability with pressure 10KN and hydraulic gradient $I = 0.5$ is: (80~140) x 10^{-6} m^3/ sec.
  - Drain probability with pressure 300KN and hydraulic gradient $I = 0.5$ is (69~80) x 10^{-6} m/sec.

2) Construction Method

The procedure of construction is as same as sand drain method.

13. MANAGEMENT AND MAINTENANCE

13.1 Present Situation of Highway Maintenance Management

(1) Organization of Ministry of Transport

Organization chart of the Ministry of Transport (MOT) is shown in Figure 13.1 and from this it may be seen that MOT has five bureaus:

- Vietnam Road Administration;
- Vietnam National Railway;
- Vietnam River Administration;
- Vietnam National Maritime; and
- Vietnam Highway Standing Committee.

(2) Vietnam Road Administration Bureau

Road administration exists within the jurisdiction of MOT. Under the Government Decree No. 07, the Vietnam Road Administration Bureau (VRAB) was formed on 30 January 1993 and it commenced operation on 26 May 1993.

The VRAB has three levels of administrative groups as shown in the following and the management is divided into 12 sections/offices:

- Management;
- Transport Companies; and
- Road Management Units.

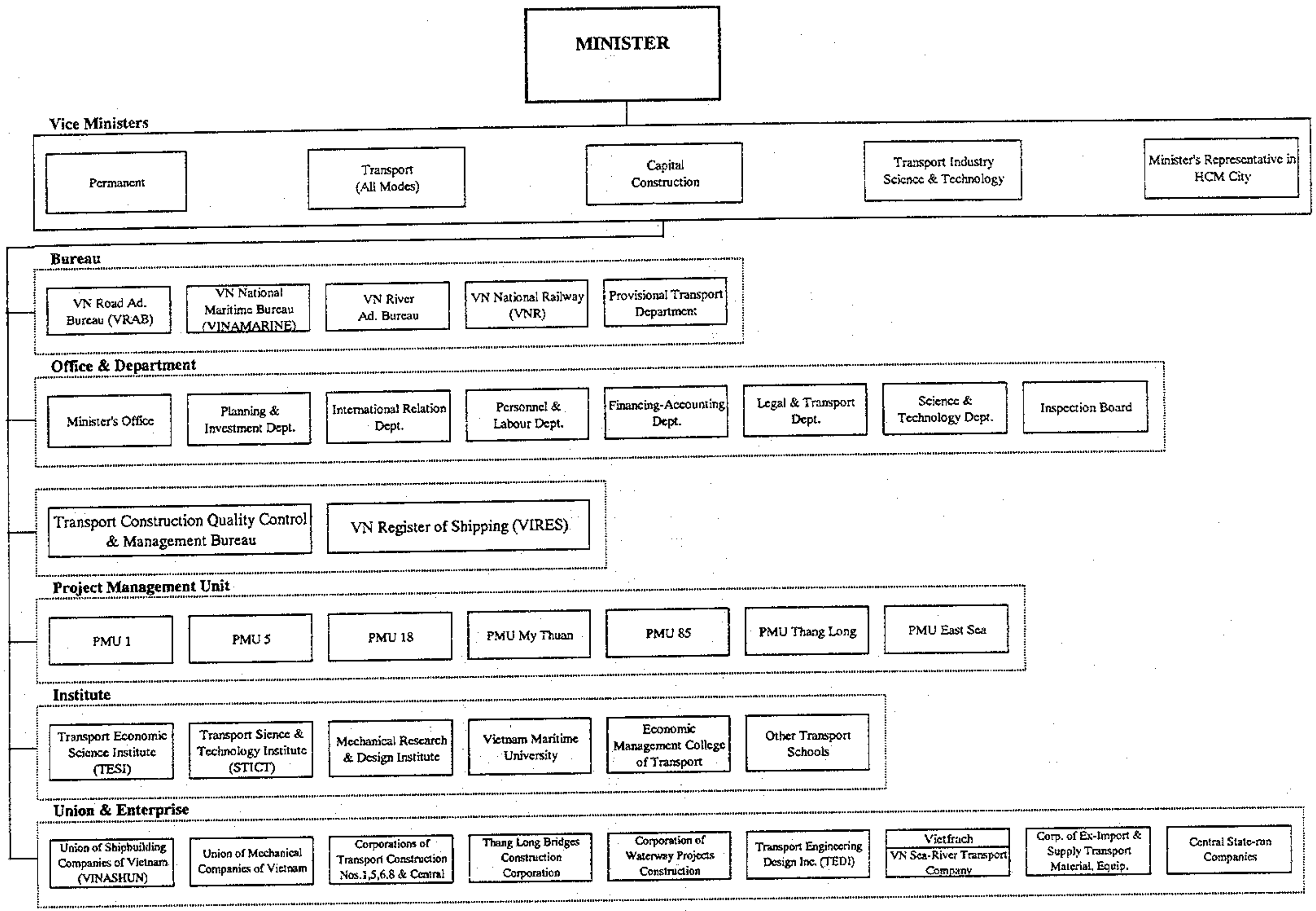


Figure 13.1 Organization Chart of Ministry of Transport

13.2 Management and Maintenance Plan

(1) System of Highway Maintenance

In order to attain proper highway management and maintenance, all systems of highway maintenance have to be carried out orderly and in a proper manner, and established organization must be consistent with the requirement of work components and needed capacities. Figure 13.2 shows the general flow chart of the recommended overall highway maintenance works.

(2) Maintenance Operating System

Highway Maintenance covers various activities related to inspections, maintenance and repairs, which require quick response and are appropriate to keep the highway open to traffic.

The following matters must be specified to implement the above operations:

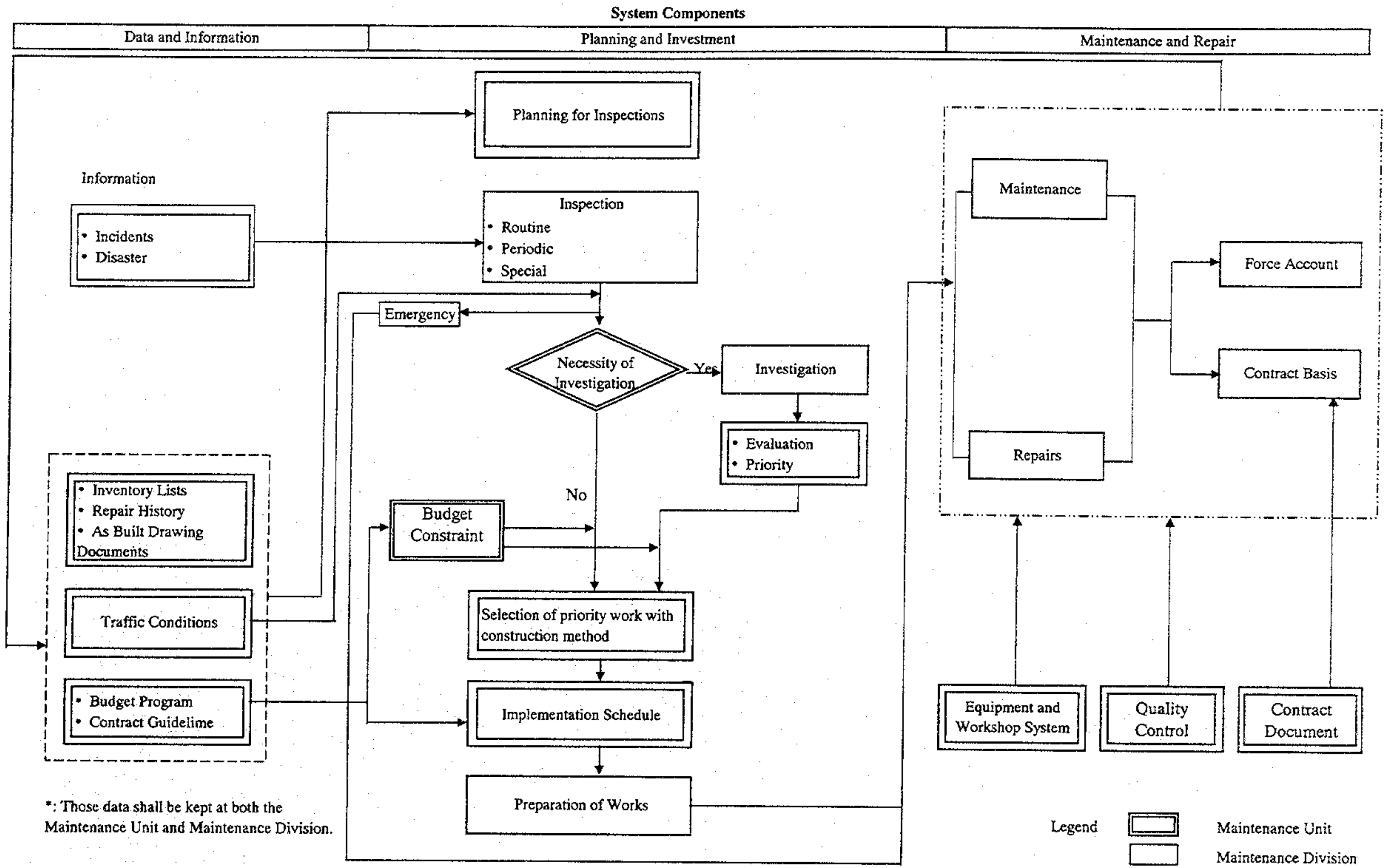
- Communications system (instruction, response, duty, decision and coordination) between headquarters of Maintenance Unit and Maintenance Division; and
- Extent of activities and responsibility of the Maintenance Unit and Maintenance Division.

The following should be considered to encourage the use of contractors to carry out highway maintenance activities:

- Maintenance activities based on a monthly and annual programme;
- Clarification of working criteria of maintenance and repairs;
- Formulation of contracts, supervision and acceptance system for highway maintenance work; and
- Provision of guidance to the contractors as to the significance of highway maintenance.

(3) Data Base and Management System

Data base and management system is indispensable for highway maintenance. One of the most important activities is to collect reliable data, in particular, to collect and keep as-built drawings and documents including design reports and specifications, construction record, and historical repair records.



*: Those data shall be kept at both the Maintenance Unit and Maintenance Division.

Figure 13.2 Flowchart of Highway Maintenance Works

(4) Activities and Tasks of Highway Maintenance

The activities and tasks of the highway maintenance are shown in Figure 13.3.

(5) Safety Measures during the Highway Maintenance

Highway maintenance will be conducted with careful consideration of traffic regulations, traffic safety and circumstances along the highway.

Personnel in charge of traffic control will be assigned during the maintenance and repairs, to ensure smooth and safe traffic flow and worker's safety.

(6) Traffic Control Measures

The date, time-frame, construction methods and proposed traffic control measures will be analyzed for the highway maintenance activities based on traffic volumes, number of traffic lanes and detours.

13.3 Recommended Maintenance and Management Body

It is recommended that a new Expressway Management and Maintenance Unit as well as Operation and Maintenance Division will be set up within the organization of Vietnam Road Administration Bureau. This will help to ensure efficient management and maintenance of SHTRR and the future Hanoi Third Ring Road.

It is also recommended that the force account activities of the Expressway operation and maintenance will be kept to the minimum level in scope and volume and the major part of the works should be done by contract basis. However, Expressway Maintenance Unit itself must undertake information collection & dissemination, and maintenance activities requiring a quick response.

13.4 Recommended Operation and Maintenance Equipment

(1) Required Vehicles and Equipment

The Division will be equipped with the following limited kinds of equipment for operation and maintenance works under such a system.

- Communication cars, patrol cars and maintenance vehicles for expressway patrol, inspection and supervision of maintenance works being carried out by the contractors;

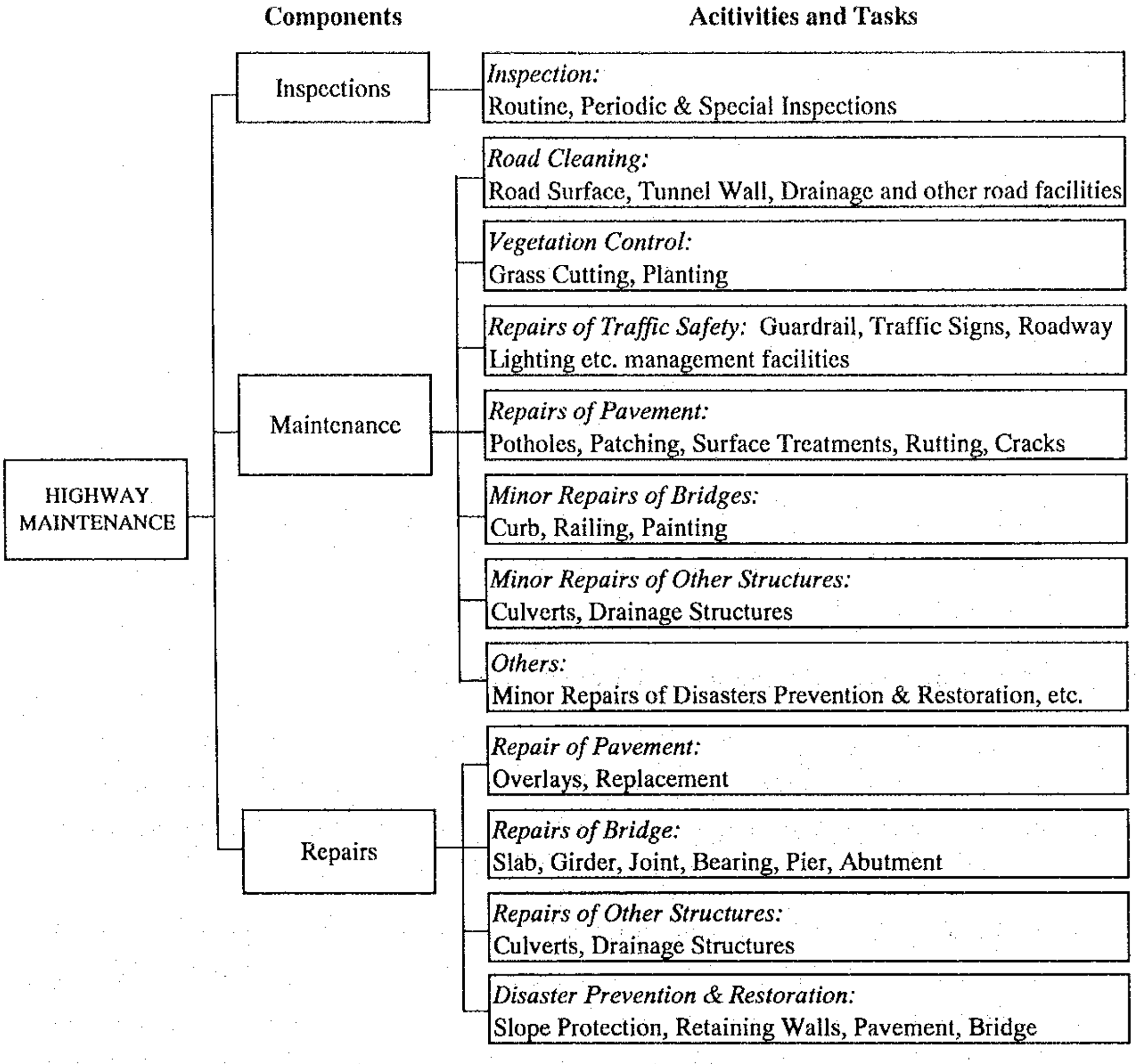


Figure 13.3 Activities and Tasks of Highway Maintenance

- Trucks, dump trucks, small crane vehicles, small rollers and tampers, air compressors, breakers, asphalt cutters, etc. for routine maintenance and emergency repair works on occasions of accident and disaster;
- Water tankers, grass cutters, etc.; and
- Ambulance vehicles.

(2) Workshop and Depots

Workshop and depot will be located near the Operation and Maintenance Division (OMD) building. However, they should be of small scale since the major maintenance and repair work will be done by Contractors under the supervision of OMD.

14. COST ESTIMATES

14.1 General

The estimates of the Project costs are based on the results of the detailed design, quantity take-off of each work item, and the studies on construction planning. The Project Cost (PC) consists of the following components:

- Construction Cost (PC1);
- Supervisory Services Cost and Administrative Cost (PC2);
- Land Acquisition and Compensation Cost (PC3); and
- Physical Contingency (Contingency).

The basic premises in estimating cost are as follows:

1) All the construction work will be executed by constructor(s) to be selected by international competitive bidding, except Package 4.
2) The unit cost of each cost component was determined based on the economic conditions prevailing in February 2000 (USD $1.0 = VND 14,000 = Yen 110.0).

14.2 Construction Cost

(1) Construction Packages

The construction is divided into the following four packages

- Package 1: Red River Bridge
- Package 2: Gia Lam Section of SHTRR
- Package 3: Thanh Tri Section of SHTRR
- Package 4: Infrastructure in the Resettlement Area

(2) Construction Cost (PC1)

Construction cost and estimated contract cost have the same meaning and comprise direct cost and indirect cost. Based on the recent JBIC loan construction practice in Vietnam, this is as shown in Figure 14.1.

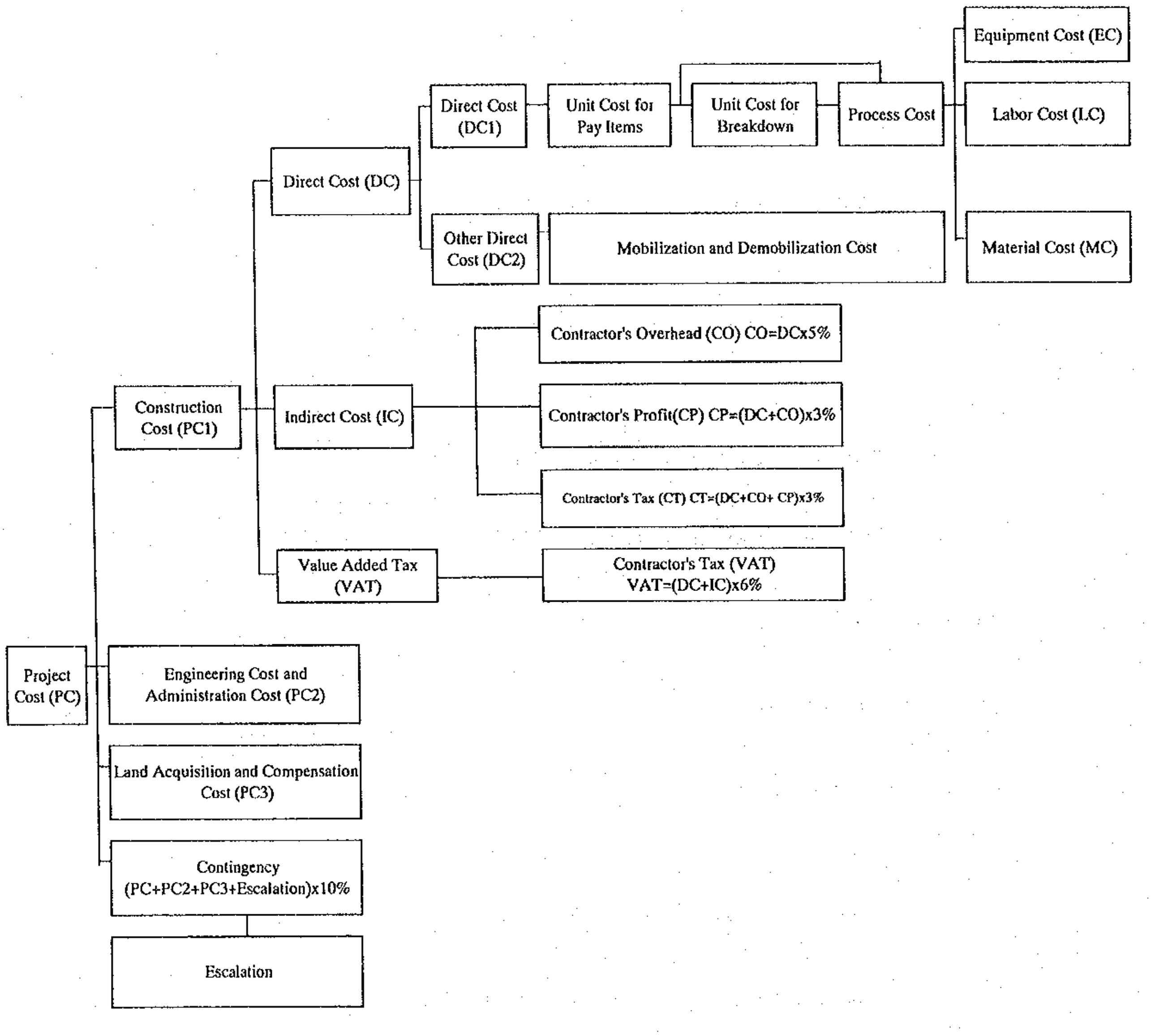


Figure 14.1 Diagram of Cost Estimate

(3) Foreign Currency Component and Local Currency Component

1) Foreign Currency Component
   - Imported equipment, material and supplies;
   - Salaries and wages of foreign personnel; and
   - Overhead and profit of foreign firms.

2) Local Currency Component
   - Domestic material and supplies;
   - Wages of local personnel; and
   - Overhead and profit of local firms.

(4) Unit Cost of Construction Works

The Unit Cost of the direct cost of construction works were studied based on the labor cost, material cost and equipment cost.

1) Unit Cost of Labor

Labor cost was calculated in accordance with the Vietnamese regulations based on:

- Basic wage by workers by grade;
- Mobilization allowance;
- Other allowances (unstable working condition, supplementary salary, social insurance, health insurance, etc);
- Income tax; and
- Average working days per month.

2) Unit Cost of Materials

Materials were classified into two groups, namely local materials which are available in the local market and foreign materials which have to be imported from the overseas market.

Local materials costs were determined based on the market prices in Hanoi and foreign materials costs were determined mainly based on the construction cost data books which are published in Japan.

3) Equipment Owning and Operation Cost

No standard for equipment owning cost / rate is available in Vietnam and a special conservative rate of owning cost was adopted considering Vietnamese construction practices.

Equipment operation cost was determined based on Japanese equipment master plant data (fuel, lubricant oil, equipment operators).

The owning cost was regarded as foreign currency component. The operation cost was regarded as local currency component and was estimated based on the market prices of fuel and unit labor cost in Hanoi.

The owning cost comprises:

- Depreciation of equipment;
- Maintenance, minor repairs and major repairs; and
- Management.

Operation cost is the sum of the following expenses:

- Fuel/ electrical power and lubricant oil and grease;
- Labor cost to operate the equipment; and
- Expendable supplies and miscellaneous expenses.

14.3 Land Acquisition and Resettlement Cost

Land acquisition and resettlement cost is estimated based on the area of required land estimated in the detailed design and the estimated building areas and number of resettled families obtained by the field investigations.

14.4 Estimated Project Cost

The estimated Project cost in 2000 prices was prepared together with the division into foreign currency and local currency portions.

(1) Consulting Services Cost

Consulting services cost was estimated as 7% of construction cost.

(2) Price and Physical Contingencies

The Government's regulation on construction cost estimates stipulates that 15% of contingency shall be considered in the estimation of contract price.

The price contingency (i.e. escalation) has been calculated at 7.5% of the amount of construction work on the basis that the assumed rates of escalation are 1.2% per year for foreign currency and 2.5% per year for local currency. Therefore, the remaining 7.5% of contingency is to be considered as a reserve for the physical contingency.

Considering the above background, the Study Team adopted 2.5% of physical contingency in the calculation of the Project cost (total physical contingency of 10%).

(3) Value Added Tax

Value Added Tax was estimated at 6% of construction and consulting services costs including contingencies.

15. PROJECT IMPLEMENTATION PLAN

15.1 Execution of the Project

(1) Executing Agency

Projects Management Unit (PMU) Thang Long of Ministry of Transport (MOT) is the Project executing agency and responsible for the execution of the following tasks:

1) Pre-construction Works
   - Engineering Services (Finalization of Detailed Design) and
   - Land Acquisition and Resettlement
2) Construction Works and Construction Supervision

The necessary land acquisition and compensation within the proposed right-of-way will be undertaken prior to the start of the construction works. The organization chart of the Ministry of Transport is shown in Figure 13.1.

(2) Procurement of Contractor(s)

Contractors for Packages 1,2, and 3 will be procured through international competitive bidding and Contractor(s) for Package 4 will be procured through domestic competitive bidding. All items to be to be financed by the JBIC shall be procured in accordance with the guidelines for Procurement under JBIC ODA Loans dated October, 1999.

(3) Consulting Services for the Project

The selection of Consultant shall be in accordance with *Guidelines for Employment of Consultants under JBIC ODA Loans dated October, 1999.*

(4) Budgetary Appropriation for the Project

Any portion of the Project cost not covered by the JBIC loan are to be financed by the budget of the Government.

15.2 Project Implementation Time Schedule

(1) Construction Package

The entire construction is divided into four packages, they are:

- Package 1: Red River Bridge
- Package 2: Gia Lam Section of SHTRR
- Package 3: Thanh Tri Section of SHTRR
- Package 4: Infrastructure in the Resettlement Area

(2) Project Implementation Time Schedule

Project implementation time schedule of each Package was drawn up as shown in Figures 15.1 through 15.4.

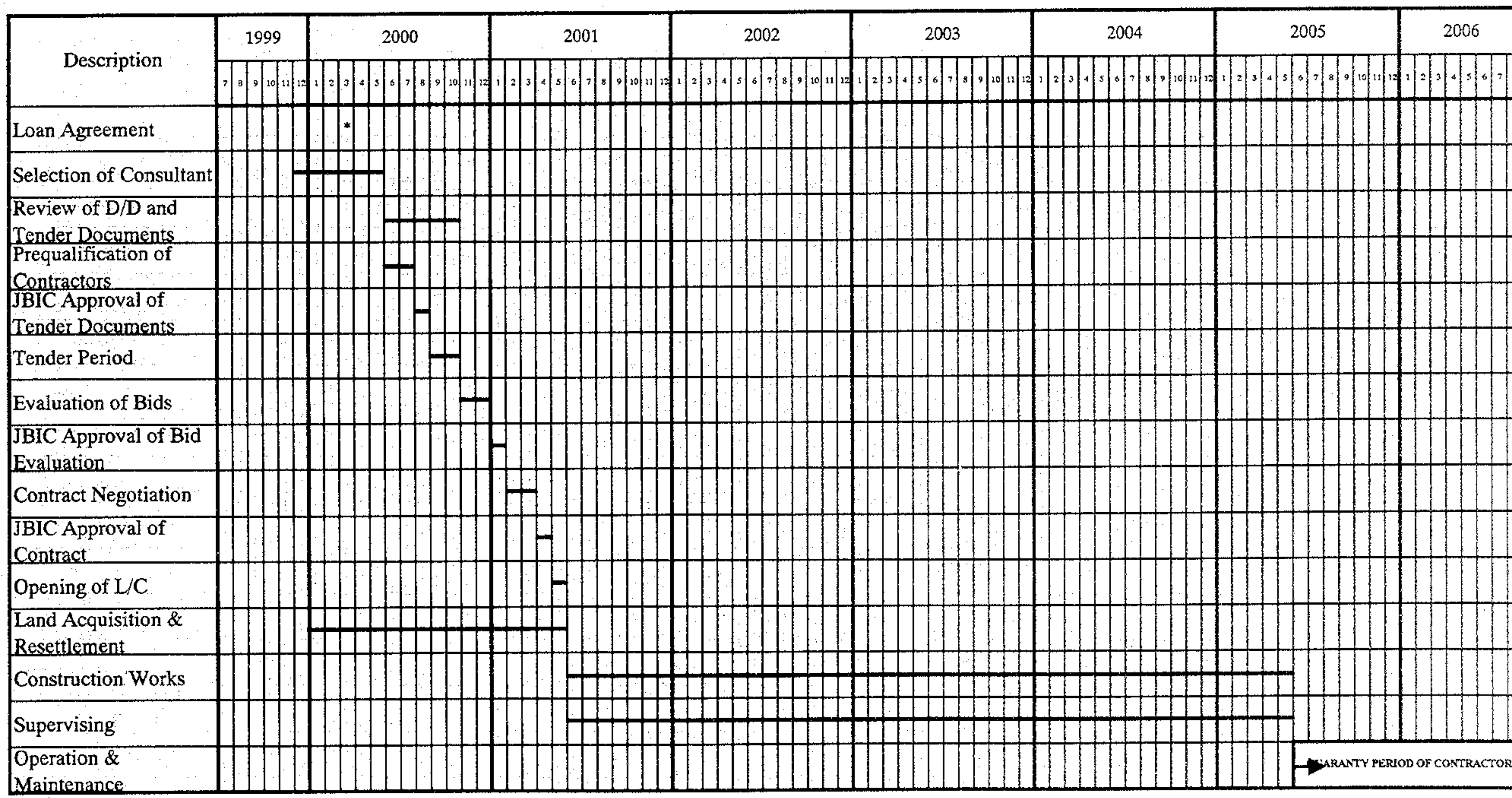


Figure 15.1 Implementation Time Schedule for the Red River Bridge Construction Project

Package 1: Red River Bridge

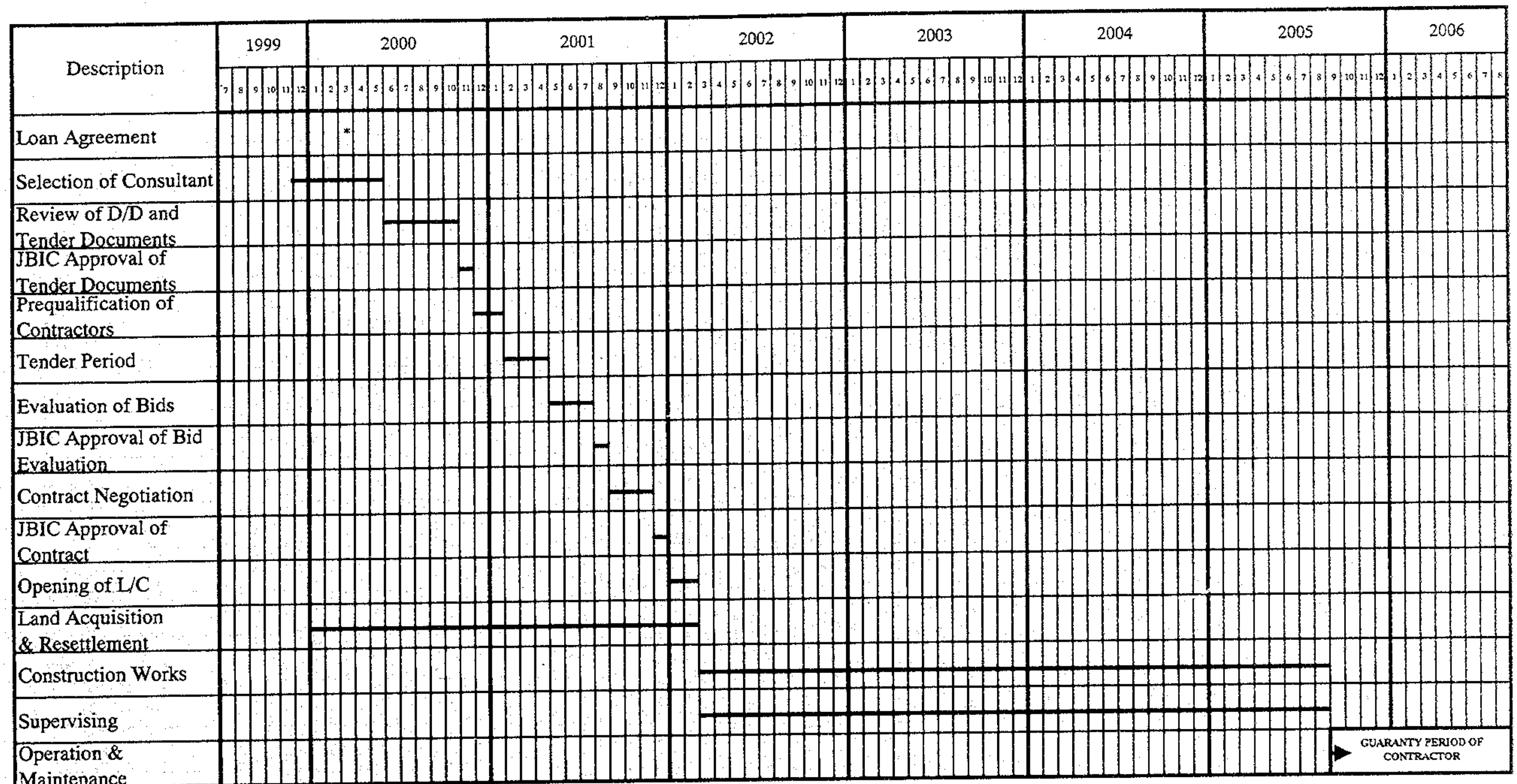


Figure 15.2 Implementation Time Schedule for the Red River Bridge Construction Project

Package 2: Gia Lam Section of SHTRR

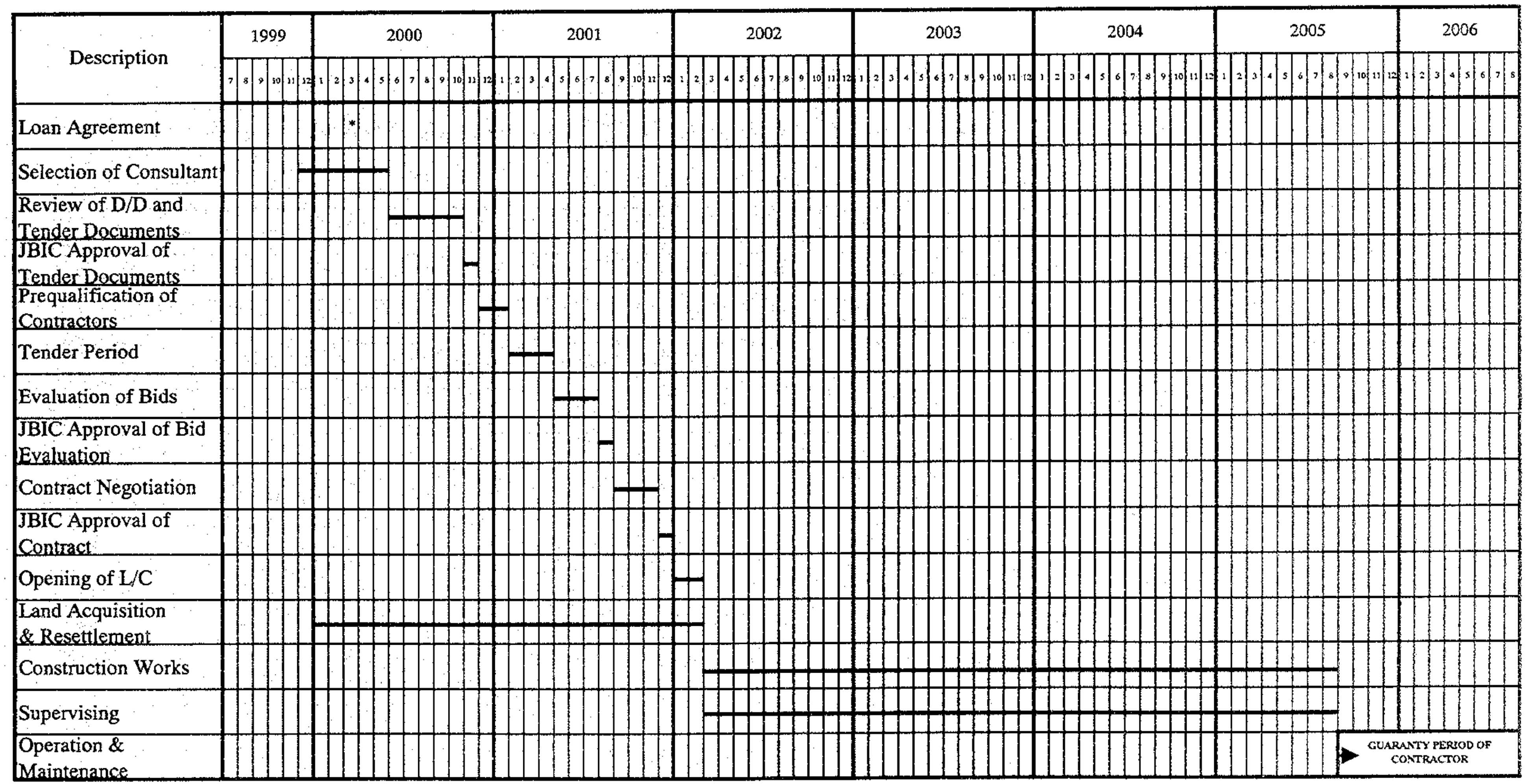


Figure 15.3 Implementation Time Schedule for the Red River Bridge Construction Project

Package 3: Thanh Tri Section of SHTRR

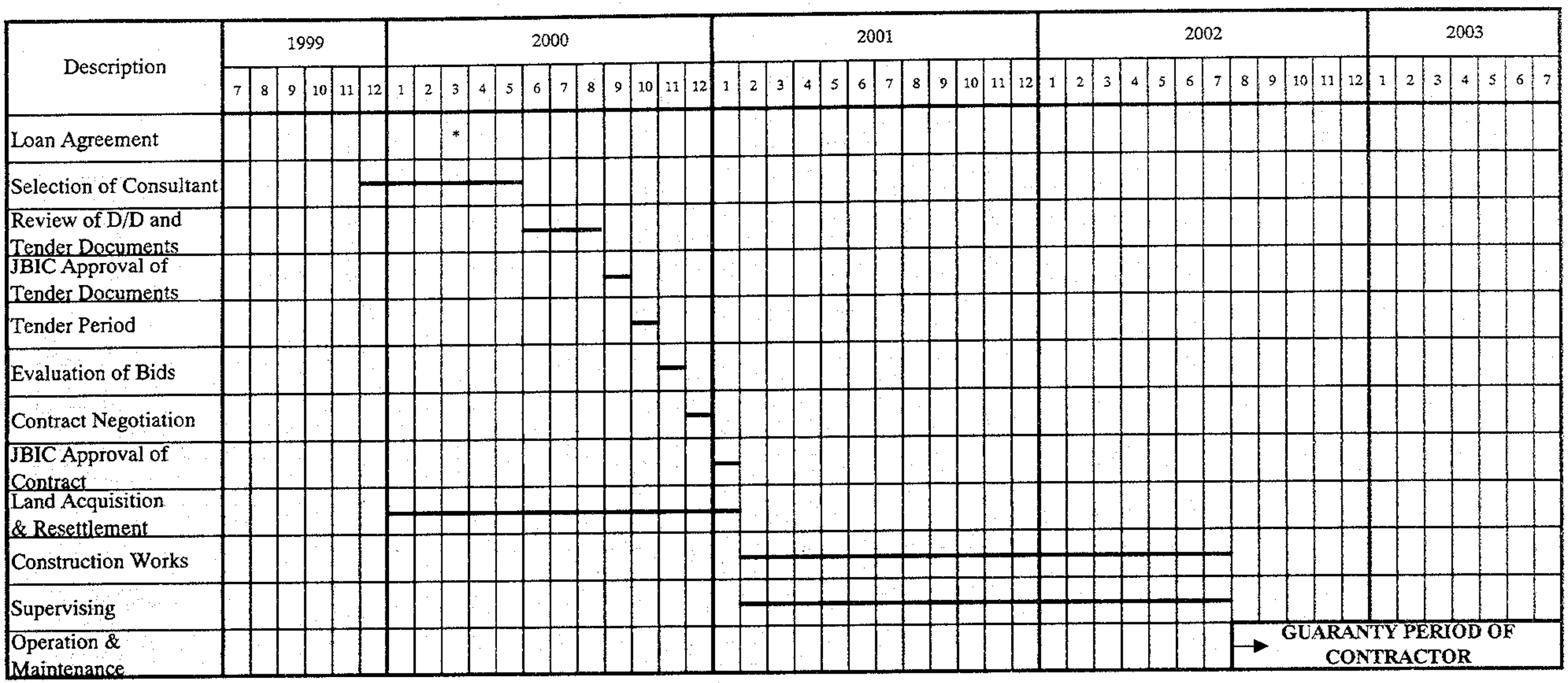


Figure 15.4 Implementation Time Schedule for the Red River Bridge Construction Project

Package 4: Infrastructure in the Resettlement Area

16. TENDER AND CONTRACT DOCUMENTS

16.1 General

In preparing the tender documents for the Project, the prevailing tendering practice of civil works in Vietnam is considered as basic conditions. In general, for tendering the documents shown in Table 16.1 are commonly used and this was confirmed by discussions with PMU Thang Long.

Table 16.1 Documents for Tender and Contract

	Instruction to Bidders
Volume I	General Conditions of Contract
Volume II	General Specifications
Volume III	Special Specifications
Volume IV	Bid, including Appendices to Bid, Bid Schedule and Schedule of Rates and Prices
Volume V	Drawings
Volume VI	Addendum (if any)
Volume VII	Detailed Work Schedule, Plant and Contractors Personnel List
	Form of Contract

16.2 Packages

The whole project is separated into four packages, three packages for international competitive tender and one package for local competitive tender.

The Red River Bridge section is named as "Package 1", the Gia Lam section is "Package 2", and the Thanh Tri section is "Package 3". Package 4 is for the construction of the infrastructure at resettlement areas.

These packages are summarized in the Table 16.2.

Table 16.2 Construction Contract Package

Package No.	Package	Tender Type
1	Red River Bridge	ICB with P/Q
2	Gia Lam Section of SHTRR	ICB with P/Q
3	Thanh Tri Section of SHTRR	ICB with P/Q
4	Infrastructure in Resettlement Areas	LCB

Note: SHTRR denotes Southern Section of Hanoi Third Ring Road.
ICB denotes International Competitive Bidding.
P/Q denotes Pre-Qualification.
LCB denotes Local Competitive Bidding.

16.3 Instructions to Bidders

Instructions to Bidders are accompanied with guide forms. This is sometimes called the Prime Document and is prepared for each of the project location specifying the site and Scope of Work.

16.4 General Conditions of Contract

The conditions contained in the document shown below are in accordance with "Conditions of Contract for Works of Civil Engineering Construction" by "Federation Internationale Des Ingenieurs-Conseils" (FIDIC) modified considering local conditions.

16.5 General Specifications

The specifications on materials and workmanship etc. are given in the General Specifications.

16.6 Special Specifications

Specifications on materials and workmanship etc. proposed by the Study which are not covered in the General Specifications are given in the Special Specifications.

16.7 Drawings

Drawings of the detailed design for each package are provided separately.

16.8 Addenda and Supplements

During the pre-bidding period, this will be prepared if necessary and issued to supplement the main Tender documents.

16.9 Detailed Work Schedule, Plant and Contractors Personnel List

A work schedule, list of construction plant and list of contractor's senior staff will be submitted together with other tender documents and Guide forms.

16.10 Form of Contract

A "Form of Contract" is also provided, so that there is no misunderstanding about the contract to be signed by the Employer and the successful tenderer.

17. ENVIRONMENTAL IMPACT STUDY

17.1 Study Objectives

The Environmental Impact Study (EIS) consists of an Environmental Study, which was conducted on May and June 1999 and an Environmental Impact Assessment (EIA), which was carried out on January and February in 2000 for the Detailed Design of the Red River Bridge Construction Project. The objectives of the EIS are as follows:

- Clarify the present environmental conditions of the Study Area;
- Analyze and forecast the possible future environmental impacts caused by the Project construction and operation;
- Formulate the environmental management plan for the Project, which includes the mitigation measures and the monitoring plan; and,
- Formulate the resettlement plan for the Project

With respect to the resettlement plan, which includes the detailed design of resettlement sites, the main contents are described in Chapter 10 and Chapter 11 of this Report.

17.2 Study Area and Study Method

The EIS Area consists of the same area as the Project Site of the Detailed Design of the Red River Bridge Construction Project Site, which includes the proposed six resettlement sites. An accurate inventory of the surroundings covers a 100 meter corridor on each side from the proposed centerline of the right of way, and the construction sites of the new facilities such as the proposed intersections. The EIS Area also includes the riparian area of the Red River, which will be located below the proposed Red River Bridge.

Based on the data of air quality, noise, and fish sampling as well as the results of the environmental evaluation of the Environmental Study, the possible significant impacts were identified. The possible future impacts caused by the Project construction and operation were forecast and analyzed. After that, based on these analysis, the environmental management plan was formulated. The management plan includes the mitigation measures and their costs, the environmental monitoring plan and its overall cost with their environmental conservation targets.

17.3 Environmental Evaluation

Based on the results of the Environmental Study and the EIA, the main aspects of the environmental evaluation during the construction and operation phase can be summarized as shown in Table 17.1.

17.4 Environmental Management Plan

(1) Environmental Mitigation Measures

Although the engineering design and construction methods will consider the mitigation measures for the possible environmental adverse impacts, the following main measures also should be taken:

Construction Phase

- Covering construction material while they are on the construction vehicles to prevent them from being blown off or falling off while in transit.
- Use of temporary dykes during the construction works to avoid discharge of toxic waste into the rivers.
- Erosion and sediment control such as re-vegetation for land disturbance areas; and
- Using heavy equipment for the construction only in the daytime period with a notice to the residents around the activity sites, as much as possible considering the construction schedule.

Operation Phase

- Sprinkling of the road surfaces twice a day at peak hours, especially in the residential area, schools, pagodas, churches, and other public facilities along both sides of the road lines;
- Provision and maintenance of planting areas along both sides of the new roads;
- Avoidance of contamination of the Red River from accidental spills, or pollutants deposited by vehicles on to the bridge pavement; and
- Consideration of a noise barrier along the Yen So Commune and Cu Khoi commune, if the other mitigation measures could not achieve the conservation targets.

The total cost of the mitigation measures will be approximately US$ 320,310.

Table 17.1 Summary of Environmental Evaluation

No.	Environmental Element	Evaluation	Main Impacts and Reasons
Social Environment			
1	Resettlement	■ (C) ■ (O)	About 1,200 households and 6,000 persons need to resettle by the Project. Also, about 120 ha of agricultural lands will be demolished. The resettlers involuntarily have to adapt to new living conditions.
2	Economic Activity	■ (C) ■ & ● (O)	Agricultural fields will be lost in some portions near the right of way. However, most of the residents for economic activities will be vitalized by the Project.
3	Traffic/Public Facilities	□(C) □ (O)	The right of way is designed to avoid passing important public facilities such as hospital, school, and community center. However, one community school at Xen So area will be demolished.
4	Community Severance	□ (C) □ (O)	As the right of way is designed to pass at only a portion of a densely commune, some community severance in the site may be inevitable.
5	Cultural Property	-	The right of way is kept away from important cultural properties except for one local Pagoda in Thanh Tri district.
6	Right of Common	-	There are no specific regulations for the water and fishing rights.
7	Public Health Condition	-	Public health issues will not be affected by the Project.
8	Waste	□ (C)	Many kinds of construction waste by the Project will generate
9	Hazards (Risk)	-	Risk of hazards will not increased by the Project implementation.
Natural Environment			
10	Topography and Geology	-	As the Project scale is not large, change of topography and geology will not occur due to the Project.
11	Soil erosion	□ (C)	Topsoil erosion by rainfall after vegetation removal may occur at the project construction phase.
12	Groundwater	-	Groundwater level/quality are in relatively good condition. Change of the distribution of groundwater will not occur due to the Project.
13	Hydrological Situation	-	Change of the river discharge and riverbed condition will not occur due to the bridge construction structures of the Project.
14	Coastal Zone	-	The Study Area does not include any coastal zone.
15	Fauna and Flora	-	There are no endangered/rare species in the Study Area and the adverse impacts on the ecosystem by the Project will be very little.
16	Meteorology	-	Change of meteorological conditions will not occur.
17	Landscape	□ (C) ● (O)	Although aesthetic deterioration may occur due to the construction wastes etc., the bridge's design is taking into account a harmony with local natural view.
Pollution			
18	Air Pollution	■ (C) ■ (O)	As the traffic volume will be increased mainly due to truck vehicles, air pollution especially SPM caused by the Project at the construction phase may occur. Air quality monitoring is needed.
19	Water Pollution	□ (C)	Increase in water pollution by the Project at the construction phase mainly due to the construction
20	Soil Contamination	-	As the construction methods will consider the countermeasures for soil contamination, the adverse impact will be little.
21	Noise and Vibration	■ (C) ■ (O)	As the right of way is designed to pass very close to houses and a Pagoda at two small sections in Thanh Tri district, the traffic noise by the Project will be affect the residents near the facilities.
22	Land Subsidence	-	As the construction methods will consider the countermeasures for land subsidence, the impact will be very little.
23	Offensive Odor	-	There are very few factors generating offensive odor by the Project.

Note: 1) Evaluation Categories

●: Potential significant favorable impact is expected. O: Potential slight favorable impact is expected.

■: Potential significant adverse impact is expected. □: Potential slight adverse impact is expected

2) (C) = Construction Phase, (O) = Operation Phase

(2) Environmental Monitoring Plan

1) Environmental Conservation Targets

The following conservation targets should be set up to maintain the desirable environmental conditions in the Study Area.

Air Quality

- Each present Vietnam's Air Quality Standards value of SPM, NO_2, SO_2, CO, CH, and Pb

Water Quality

- Each present Vietnam's Water Quality Standards value of pH, SS, COD, BOD, DO, P_{total}, Al, and Fe.

Noise

- 80 dB (A) during the construction phase
- 75 dB (A) during the operation phase

2) Monitoring Items

Construction Phase (year 2001 to 2005)

Category	Air Quality	Water Quality	Noise
Sampling Point	5 points	3 points	5 points
Frequency	1 day/month for 5 years	2 times/week for 5 years	1 day/month for 5 years
Sampling Items	SPM, SO_2, NO_2, CH, CO, and Pb	pH, SS, COD, BOD, DO, P_{total}, Al, and Fe	Leq

Operation Phase (year 2006 – 2010)

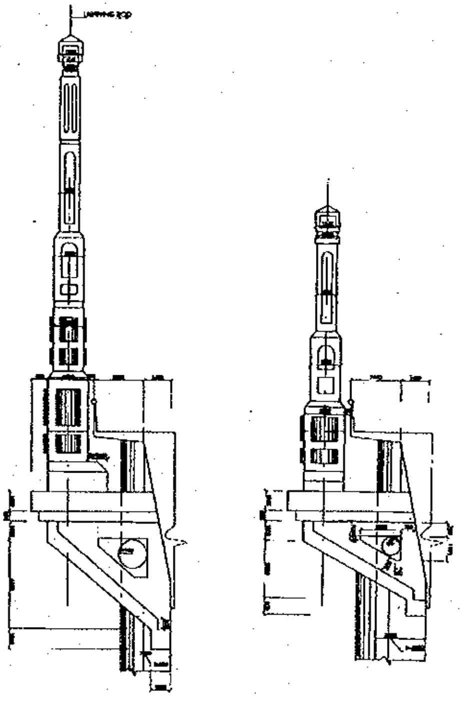
Category	Air Quality	Water Quality	Noise
Sampling Point	5 points	3 points	5 points
Frequency	1 day/ 6 month for 5 years	2 times/month for 5 years	1 day/6 month for 5 years
Sampling Items	SPM, SO_2, NO_2, CH, CO, and Pb	pH, SS, COD, BOD, DO, P_{total}, Al, and Fe	Leq

The total cost of the environmental monitoring will be approximately US$ 156,000.

18. LANDSCAPES

Landscape works in the Than Tri Bridge project are intended to develop the project as a symbolic existence and also to establish an identifiable landscape object over the Red River. For vehicle drivers the proposed bridge towers will be recognized as the passing point while driving across the bridge. The towers will also become a new landmark and a symbolic memorial for the 21st. century in Hanoi. Frontage road is to be provided along with the third link road, since the frontage road will function as a collector road serving for community activities. Sidewalk of the frontage road is to be furnished with roadside trees and these will lead to enhancement of the community township landscape and environment. For species selection, a balanced form with good crown shape and shadow provision for hot season is required. Periodic blooming of flowers is also desirable and the chosen trees should be hardy in nature and able to grow with low maintenance. The recommended species are Queen crape -myrtle and Golden shower, and planting interval of the road side trees shall be an average of 8m.

Planting will also be provided in the site of the administration office at toll plaza and administration office of the road department for enhancing these facility spaces.



Main Bridge Tower Sub Bridge Tower

Figure 18.1 Elevation of Main and Sub Bridge Towers

The Red River Bridge top forms a longer continuous flat, and perception by drivers would be that the bridge seemed rather simple and long while driving across it. The bridge towers are intended to contribute by providing a landscape focus and enhancing the bridge top scenery. The bridge towers are composed of two pairs of main tower and also sub tower, and they will become a distinctive landmark of the Red River Bridge as a whole. The main bridge tower is facilitated at the end pier of the dyke bridge. The tower foundation is 9.3m in height and the tower is 21.35m in height. The design of the bridge tower is based on the inherited art-deco style, which Hanoi citizen have been much fond of. The sub-bridge tower is provided at both pier ends of the main bridge. The foundation is 9.15m in height and the tower is 13.1m in height. Figure 18.1 shows elevations of the main and sub bridge towers.

19. ECONOMIC AND FINANCIAL ANALYSIS

19.1 Economic Analysis

(1) Project Cost

Project cost is estimated by market price and then the market price is converted to the economic cost to express real value of resources used in the project, and to compare economic benefits for project justification.

(2) Traffic Demand

The traffic volume derived in the feasibility study is used for the benefit calculation this time. The traffic is expected to use the whole section of 12.3km, and also the partial section of 4.8km, on the expressway.

Table 19.1 Traffic Volume on Project Road in the Target Year

Unit: Vehicle/day

Year	Passenger Car	Bus	Truck	Motorcycle	Total
2010	8,619	6,044	14,375	116,253	145,291
2020	40,337	8,223	21,171	59,709	129,440
Increase Rate	16.7%	3.1%	3.9%	-6.4%	

(3) Benefit

The economic benefits quantified were the saving in vehicle operating cost and time cost. Time cost saving can be obtained from the difference between traveling speed on expressway with project and traveling speed on city road without project. The following value unit is used for estimation of passenger time benefit.

1) Time value per minute ....Passenger car .... 164.67 dong /minute
2) Time value per minute ....Bus ....426.41 dong /minute
3) Time value per minute ....Motorcycle .... 43.13 dong /minute

Vehicle operating cost saving from higher design standards and shortening traveling distance by project, are estimated simultaneously.

(4) B/C Ratio and NPV

Total discounted benefit is bigger than total discounted cost, which proves that the investment amounting to 5,088,417 million dong of Thanh Tri project is economically feasible.

- Benefit Cost Ratio discounted at 12% 1.18
- Net Present Value discounted at 12% 594,854 million dong

(5) Economic Internal Rate of Return

Project is judged feasible and proves economically feasible from the national point of view, showing EIRR of 13.49%, higher than 12% of the opportunity cost of capital in Vietnam.

(6) Sensitivity Analysis

Table shows possible change of EIRR by the degree of influence of future uncertainty at cost increase and benefit decrease of the project in the case of base case.

Table 19.2 Sensitivity Analysis of Economic Indicator

Unit: EIRR

		Benefit Decrease			
		0%	-10%	-15%	-20%
Cost Increase	0%	13%	13%	12%	11%
	10%	13%	12%	11%	11%
	15%	12%	11%	11%	10%
	20%	12%	11%	10%	10%

19.2 Financial Analysis

(1) Result of Financial Internal Rate of Return Analysis (FIRR)

1) Toll Charge and Users' Surplus

Vehicle operating cost saving and passenger's time cost saving with and without project is estimated as user benefit. The level of toll used for financial analysis is given in the following two cases and shown in Table 19.3.

i) Toll-benefit ratio.........Average 35% as toll and 65% as users' surplus,
ii) 20% increase of the ratio...Average 42% charge on toll and 58% as users' surplus.

Table19.3 Setting Up Toll Level by Vehicle Type for Project Life

Dong / one trip

Toll applied the same toll /revenue ratio in year 2000					
	P. Car	Bus	Truck	M.Cycle	Average
T/B Ratio	30%	41%	46%	24%	35%
Toll applied 20% Increase					
	P. Car	Bus	Truck	M.Cycle	Average
T/B Ratio	37%	49%	55%	28%	42%

2) Result of FIRR Analysis

FIRR shows the discount rate in which total discount present value of cost equals to the total discounted present value of toll revenue. In the case of this project, the FIRR is 4.18%, which is relatively low.

The following are the results of the FIRR sensitivity analysis:

i) FIRR for the Base Case 4.18%
ii) With 20% increase of toll fee 5.48%
iii) Including interest (1.8%) during construction 4.14%
iv) Decrease of routine maintenance cost from 0.6% to 0.15%..........4.50%
v) Toll free for motorcycle 3.56%
vi) Toll free for motorcycle, with and increase of 20%
in toll charges for other vehicles 4.18%

3) Tentative Conclusion

As analyzed above, the FIRR is lower than 6%, ranging from 3.6% to 5.5%. In the case of operation by a private company, the FIRR should be higher than 10%, as this includes for 2% of dividend and 3% of profit. The project is therefore not feasible to be implemented by the private sector.

(2) Result of Net Cash Flow Analysis

1) Debt Condition by Sources

Following alternatives were assumed in the financing structures:

i) Soft loan; Rate of interest: 1.8%
ii) Repayment period: 30 years including 10 years grace period
iii) Government financing; Rate of interest: 0%
iv) Repayment: 15 years
v) Bank loan; Rate of interest: 10%
vi) Repayment period: 15 years
vii) Equity; Private concessionaire, other private domestic companies

2) Estimation of Capital Investment Cost by Fund Resources

Table 19.4 shows the 6 cases of the combination of capital cost by debt structure.

Table 19.4 Summary of Capital Investment Cost by Fund Recourse

(at Constant Price in Year 2000) Unit: Billion Dong

Year	Base Case	1) Implementation by Government				2)Implementation by Private	
		Case 1 56%:Soft Loan 44%: G.Finance	Case 2 56%:Soft Loan 44%:BankLoan	Case 3 80%:Soft Loan 20%:G.Finance	Case 4 80%:Soft Loan 20%:Bank Loan	Case 5 70%:Soft Loan 30%:Equity	Case 6 56%Soft,14%Bank 30%:Equity
2000	323	326	341	328	334	327	330
2001	447	456	498	460	479	458	469
2002	1,060	1,092	1,247	1,106	1,176	1,100	1,140
2003	1,396	1,454	1,740	1,479	1,609	1,469	1,543
2004	1,387	1,459	1,832	1,490	1,659	1,477	1,576
2005	476	515	677	528	601	523	566
Total	5,088	5,303	6,334	5,391	5,859	5,354	5,624
Order		6	1	4	2	5	3

Note(1) Working Capital 9,269Million Dong is included in local fund in Year 2005

The cost is shown in constant price of the year 2000 and does not include price contingency. Foreign component of the project is 56%.

3) Negative Cases of the Result of Cash Flow Balance

i) Case 2: Project cannot meet long term debt service in first 17 years.
ii) Case 4: Project cannot meet long term debt service in first13 years.
iii) Project cost of case 2 and case 4 cannot meet long term debt service even if the level of toll fee is increased by 20%.

These alternatives must therefore be rejected.

4) Positive Cases of Cash Flow Balance by Minor Adjustment

i) Case 1: Project cannot meet long term debt service for 8 years from 2010 to 2017 because of the shortage of revenue, which cannot cover the repayment of principle and interest.
ii) Case 3: Project cannot meet long term debt service for 2 years from 2015 to 2016.

In both of these case of cases, project income will meet long-term debt service obligations with a very limited increase of 20% of toll fee.

Table 19.5 Result of Appraisal of Cash Flow Analysis

Case	Soft Loan	Bank Loan	G.Finance	Equity	Appraisal		
					35%T/B Ratio	42%T/B Ratio	Judgement
Case 1	56%		44%		X	O	Negative in Principle
Case 2	56%	44%			X	X	Negative
Case 3	80%		20%		D	O	Acceptable in principle
Case 4	80%	20%			X	X	Negative
Case 5	70%			30%	O	O	Acceptable
Case 6	56%	14%		30%	O	O	Acceptable with Difficulty

5) Conclusion

i) Implementation of project by 100% of private sector is judged to be financially unfeasible since FIRR is less than 6%

ii) For implementation by the government, the fund combination with interest on the government loan and bank loan is not feasible because of the shortage of revenue, which cannot cover the repayment of principle and interest.

iii) There is a need to increase toll charge when the project is implemented by the fund resources with soft loan and government financing

iv) Private concessionaire needs to participate in the project when the government cannot prepare the 20 % of project cost of without interest. In this case, the government needs to prepare soft loan of 70% of the project cost based on government guarantee to the soft loan provider.

v) Implementation by private concessionaire is not easy to participate with 30% of equity of the project cost since FIRR is very low and not profitable. In this case, the Government needs to consider to give some considerations such as tax exemption or increase of toll fee.

20. CONCLUSION AND RECOMMENDATIONS

20.1 Necessity of the Project

The Project for the construction of the Thanh Tri Bridge and Southern Section of Hanoi Third Ring Road (SHTRR), is of great importance for the development of the Hanoi capital region and is expected to play the following important roles:

- To improve and strengthen the road network in Hanoi capital region to cope with the future increase in vehicle traffic demand and rapid development in the region;
- To provide a by-pass road of National Highway No.1, since the existing roads in Hanoi central business district are seriously congested, especially in National Highway No.1 corridor; and
- To encourage development of Hanoi to the west and north of the red River by an increase in the traffic handling capacity of bridges crossing the river.

20.2 Conclusion on Technical Aspects

(1) Selection of Type of Highway for Throughway in the Phap Van Area

On the section between Phap Van –Cau Gie Interchange and National Highway No.5 in the Phap Van area, both the at-grade type and the viaduct type were studied from the standpoint of road geometric structure, embankment stability, construction cost, landscaping and environment and land / house compensation. From the result of the study, the viaduct was superior to the at-grade type and selected as the recommended option.

(2) Selection of Single Trumpet Type for Phap Van – Cau Gie Interchange

The interchange between STA 0+000 and STA 0+800 is to manage the traffic flow between the Phap Van - Cau Gie road and SHTRR and also between the NH1 and the SHTRR. Two types of interchange (clover leaf type and single trumpet type) were studied from the point of view of the construction cost, land acquisition and compensation expense, trafficability and accessibility. From the study result, single trumpet type is superior to the clover leaf type and selected as the recommended interchange type.

(3) Selection of Red River Bridge Type

Red River Bridge consists of the Main Bridge and Approach Bridge. The Approach Bridge is subdivided into Approach Bridge 1, Dyke Bridge and Approach Bridge 2.

After the review of F/S and comparison study regarding the bridge types from technical and economical view points, the following bridge types were selected for the Red River Bridge.

Main Bridge:	Superstructure:	Continuous PC Box Girder Bridge (Cantilever Erection Method) 80 m + 4 @ 130 m + 80 m = 680 m
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 2.0m

Approach Bridge

Approach Bridge 1:	Superstructure:	Continuous PC Box Girder Bridge 50m span base
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 1.5
Dyke Bridge:	Superstructure:	Continuous PC Box Girder Bridge (Cantilever Erection Method) 80 m + 130 m + 80 m = 290 m
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 1.5m
Approach Bridge 2:	Superstructure:	Simple PC I-Girder Bridge 33m span base
	Foundation:	RC Cast-in-situ Pile (Reverse Circulation Method) Diameter: 1.0m

(4) Major Design Features

1) A design speed of 100 km/h is applied to the throughway and 60 km/h to the frontage roads.

2) The lane width is 3.75m for the throughway and 3.50m for the frontage roads.

3) Number of lanes of throughway in each construction package is shown in the following table.

Package No.	Section	Number of Lane
1	Thanh Tri Bridge	6
2	Thanh Tri	4
3	Gia Lam	4

4) The width of the throughway in the interchange section was decided taking account of the future stage II throughway (6 lanes). This will avoid the difficulty of the additional work after the road is open to traffic.

5) Five interchanges: Phap Van - Cau Gie (Single Trumpet); Nguyen Tam Trinh (Half Diamond); Linh Nam (Full Diamond); Gia Lam Dyke (Half Diamond); and NH5 (Half Clover Leaf) were designed.

6) From the standpoint of efficient collection of toll fee, geological condition of the site and road alignment, a barrier type toll gate included in Package 3 was proposed at a location between the Linh Nam Interchange and the Thanh Tri Dyke road

7) Flexible pavement was designed with a view to lower initial investment cost, better adaptability in embankment section and more comfortable riding condition than rigid pavement.

8) Bridge Design Loads

- 125% of the standard AASHTO HS20-44 truck or lane loads was used in the design. H30 and XB80 live loads specified in VNBDC are also considered

- The collision forces to be considered in the design were calculated in accordance with AASHTO LRFD specification based on the maximum ship and the maximum barge weights.

- Seismic acceleration coefficient of 0.17 was adopted considering the natural conditions in the study area and recommendation by the Institute of Geophysics of Vietnam National Center for Natural Science and Technology.

20.3 Recommendations

(1) Implementation of the Project

The results of the Study indicate that the Project is technically sound (no serious technical difficulties are anticipated for the construction) and also economically feasible. Taking into account the direct and enormous indirect benefits towards regional development other than the quantified savings in travel costs, the Project should be implemented at the earliest opportunity.

(2) Land Acquisition and Resettlement

Delay of implementation would entail increasingly difficult land acquisition and resettlement due to the rapid development of the region, especially in Thanh Tri area. Arrangement of land acquisition and resettlement should commence immediately

(3) Project Implementation Schedule

Proposed implementation schedule is to emphasize simultaneous commencement of services in all four packages, subject to due consideration on inevitable lead-time for land acquisition and resettlement, to optimize investment schedule.

(4) Construction Scheme for the Future Widening

A stage construction scheme such as widening from four lanes to six lanes in the future will entail immense technical difficulties when applied to Thanh Tri Bridge, Pahp Van – Cau Gie Interchange and National Highway No.5 Interchange. Thus it is recommended to provide a six-lane width in the initial stage to avoid this problem, even though only four lanes will be required initially.

(5) Environmental Evaluation

Based on the results of Environmental Study and the EIA, the environmental measures shall be provided during the construction and operation phases.

(6) Maintenance and Operation after the completion of construction

In order to maintain the smooth traffic conditions and safeguard the investment, the maintenance and operation shall be adequately planned and provided for.

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